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NINTH REPORT

OF THE

HENRY PHIPPS INSTITUTE

FOR THE STUDY, TREATMENT, AND PREVENTION OF TUBERCULOSIS

PUBLISHED BY THE
HENRY PHIPPS INSTITUTE
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EXPERIMENTAL PULMONARY TUBERCULOSIS IN THE DOG.

THE EFFECT OF LARGE AMOUNTS OF TUBERCLE BACILLI OF BOVINE TYPE INTRODUCED DIRECTLY INTO THE LUNGS BY WAY OF THE AIR PASSAGES.*

BY PAUL A. LEWIS, M.D., AND CHARLES M. MONTGOMERY, M.D.

(From the Henry Phipps Institute of the University of Pennsylvania, Philadelphia.)

PLATE 101.

This study was undertaken because of the apparent desirability of having at our command methods of reproducing as nearly as possible in experiment the conditions that prevail in chronic pulmonary tuberculosis.

Chronic pulmonary tuberculosis presents a complex picture, the result of the interaction of a number of factors. Important among them are, first, the severity of the infection as represented by the number and possibly also the virulence of the bacilli gaining entrance to the lungs; second, the resistance of the individual to infection as manifested in the reaction to the primary contagion and as modified during the course of the disease either by the specific reactions of immunity and hypersusceptibility or by physiological changes not directly associated with the disease; and third, the complication with other diseases and infections, particularly the direct secondary infection of the affected lung tissue.

Thus far we have been no more successful than our predecessors in so combining the various factors under controlled conditions as to reproduce chronic pulmonary tuberculosis with all its characteristic features. Nevertheless these factors, or some of them, are of decisive influence on the result of any experimental production of

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* Read before the Pathological Society of Philadelphia, October 12, 1911. Received for publication, February 17, 1913.

tuberculosis, and the fact that we have failed so far to reproduce in characteristic form the complete picture cannot lead to the conclusion that it would not be possible to do so by altering the conditions of the experiment.

We have, in the course of work to be described, reproduced almost exactly a certain rare form of tuberculosis of the lungs, acute tuberculous lobar pneumonia, and on this account we feel that the experiments are worthy of brief description. This is especially so in view of the fact that we have closely followed the technique by the use of which Lamar and Meltzer (1) succeeded in producing an acute lobar pneumonia with the pneumococcus, and with which Wollstein and Meltzer (2) later produced lobular pneumonia with the streptococcus. Our results may lend further significance to their work.

Assuming that the final result of our experiments would depend in large measure on the balance between the resistance of the dog, commonly classed as highly resistant, and the virulence of the culture, we selected for our work a culture from human source, but of bovine type, known to be virulent for guinea pigs, rabbits, and cattle. Actively growing cultures between ten days and two weeks old were used. The culture was thoroughly emulsified in salt solution by the use of an agate mortar. The small clumps remaining were disregarded. Ten cubic centimeters of salt solution were used for each culture tube, the culture mass weighing approximately 100 milligrams. In most of the experiments ten cubic centimeters of the emulsion were administered. In a few instances one cubic centimeter was given further diluted with nine cubic centimeters of salt solution.

The mode of administration was as follows: The dog, etherized to the point of complete relaxation, was laid on its back. The mouth was opened and the epiglottis brought forward until the orifice of the larynx was plainly visible. A medium sized soft catheter was then inserted into the larynx and pushed on through the trachea until it was judged that the opening was below the bifurcation. The catheter was then quickly attached to the syringe containing the emulsion and this was injected slowly. The catheter was quickly removed and the animal was allowed to turn on its right side. During removal from the table to the floor the animal was kept on its right side with the head somewhat higher than the tail. Recovery from the procedure was always prompt and unaccompanied by cough or other symptoms of distress.

It may be said here that at autopsy it was found that in all instances the inoculation had been made chiefly into the right caudal lobe. In most instances there was a considerable diffuse consolidation of the right middle lobe and some focal involvement of other lobes, particularly the left caudal lobe.

Following the injection the animals show no marked changes for five days. In from six to nine days they begin to cough. The cough, at first occasional, gradually becomes frequent and severe. At about the same time the animal begins to lose weight and condition. The loss of weight is progressive and at the time of death it amounted frequently to one third, and has sometimes been nearly one half of the original weight.

Percussion and auscultation show a well defined progressive consolidation beginning with indefinite signs about the time of the cough and becoming pronounced a few days later. It is perfectly possible to follow the course of the lung lesion by clinical methods, but the conditions do not permit of the accurate observations attained by Opie (3) in his study of the pleural exudates in the dog.

The temperature of some animals has been taken throughout the course of the infection and in others at irregular intervals. No fever has at any time been noted.

In only one case has there been any complication. One animal in a severe fit of coughing caused a pin point rupture in a healthy portion of the lung, developing a pneumothorax. This was at first unilateral but became bilateral a few hours later and the animal died. Most of the animals in the series died or were killed when moribund. A small number were killed in the earlier periods of the experiment in order to follow the course of development of the lesion.

POST-MORTEM EXAMINATIONS.

On gross examination at autopsy, there was always found a consolidation of the lung varying in extent and character with the length of time the animal had survived the inoculation and the amount of culture administered.

In the usual case the consolidation was found most pronounced in the right caudal lobe. Where the larger amounts of culture were given, this lobe was completely or almost completely pneumonic. The consolidation varied somewhat in color and consistency. In the earlier cases (before the fourteenth day) whether the animal died or was killed the color was reddish gray. Later it was gray, yellowish gray, yellow, and in one late instance almost white. The tissue was firm, quite dry, and very little material could be scraped off with light pressure on the knife. In the later stages there was a tendency for the tissue to soften in spots, and in those cases examined between the seventeenth and the twenty-fourth days the softened matter had frequently been discharged through a bronchus, leaving a cavity.

The cavities were variable in distribution and shape. Sometimes they were large and single. In other instances they were small, irregular, and connected to form ramifying excavations throughout the lobe. In the formation of the cavities the blood vessels were frequently left exposed. No instance of hemorrhage from this source was noted. There was no tendency towards the formation of a membranous wall in connection with the excavations. Figures 1 and 2 illustrate the types of cavities found.

In the animals examined more than three weeks after infection there was always a miliary tuberculosis of the unconsolidated portion of the lungs, the spleen, the kidneys, and especially of the liver.

The pleuræ over the consolidated areas were usually somewhat dull. When the cavities approached the pleural surface the pleura was always definitely thickened. In no instance was there a definite pleural exudate.

The earliest microscopic examinations made have been of animals dying or killed ten days after inoculation. The process at this time is entirely exudative in character. The character of the exudation is extremely variable when the alveoli are considered. Alveoli showing the various types of exudation are, however, so intermingled as to make it impossible to consider that the exudation has first affected particular regions and spread to others. The contents of single alveoli are usually predominantly of one order. Many alveoli are filled with fibrin and show very few cells. Others contain predominantly red blood corpuscles, while still others show chiefly leucocytes. Of the alveoli showing leucocytes many have chiefly polymorphonuclear cells, while others show mostly endothelial phagocytic cells. Cells of endothelial type are also found in large numbers in the smaller blood vessels, particularly in the dilated capillaries of some of the alveolar walls. Cells of this type both in the vessels and in the alveoli are actively proliferating, as evidenced by the presence of numerous karyokinetic figures.

At this period the contents of single alveoli and in a few instances of small groups of alveoli begin to show necrosis. Bacilli are most numerous in the necrotic areas. Small groups of bacilli are found in other areas. While the bacilli are sufficiently numerous to be demonstrated with ease there are probably less at this stage than the number originally introduced.

From the fourteenth to the twentieth day necrosis and caseation become more extensive. The necrosis, as indicated above, seems always to begin in the exudate. When it becomes well marked the adjoining fixed tissues become involved. Cavity formation may occur when the fixed tissues are involved in the necrosis. In this type of lesion, at least, cavity formation occurs by a necrosis extending into the bronchus from the surrounding exudate. No instance of a primarily ulcerated bronchial mucosa has been observed. In this period also the visceral pleura becomes thickened. The bacilli increase rapidly in number and at the end of the third week are extremely abundant. The order of the changes described has always been observed in this series of experiments but the division into periods is arbitrary, as the process varies in its rapidity of progress in different animals. One animal, for example, dying twenty-two days after inoculation, showed the microscopic picture described for those dying or killed about the tenth day.

The cavities that are formed correspond in some particulars to the cavity of chronic tuberculosis. Particularly the blood vessels show a considerable resistance to ulceration and remain intact, exposed in the cavity. In other particulars correspondence is entirely lacking. The wall of the cavity is composed of a necrotic exudate which differs very little microscopically from the detached contents. Macroscopically the exudate in the cavity is moist while that of the wall is relatively dry.

After the twentieth day in most cases there are some evidences of a reparative process. The special stains for connective tissue begin to bring out foci of its formation. The arrangement of the newly formed connective tissue is, however, without order,—especially it has no definite relation to the walls of the cavities. As a reparative process the connective tissue formation is entirely inefficient throughout the period of these experiments.

BACTERIOLOGY.

The rapid increase in the number of tubercle bacilli in the later periods of the experiment has been noted. Cultures have been made and sections examined for other bacteria. As a rule, none have been found. It is especially important that even in most instances of open cavity formation the cavities contained only the tubercle bacillus. In the few instances noted where secondary infection was observed it could not be shown that the character of the process had been in any way influenced thereby.

DISCUSSION AND CONCLUSIONS.

It is obvious, as stated in the beginning, that these experiments have failed to reproduce a chronic pulmonary tuberculosis. Acute pneumonic processes of tubercular origin are, however, not infrequent as a complicating or terminal process in pulmonary phthisis, and there have been several cases described in which individuals have died with the symptom complex of acute lobar pneumonia, in which it developed at post-mortem examination that the disease was tuberculosis. Our experiments throw some light on debated questions in connection with these acute pneumonic forms of phthisis.

Orth (4) argues for a distinctively exudative form of tuberculosis as contrasted with the productive form which leads to tubercle formation. He lays especial stress in this connection on the presence of a fibrinous exudate in alveoli with normal walls. He notes that red blood corpuscles and white cells are frequently associated with the fibrin. The white cells usually predominate. These fibrinous masses usually contain tubercle bacilli and they tend to become caseous from the center. Associated alveoli are found, filled with endothelial or epithelial cells. Orth believes, in opposition to von Buhl and Baumgarten, that the evidence that these are desquamated epithelial cells is scanty and thinks that they are more apt, in part at least, to come through the blood. Orth does not speak of cavity formation in this connection but considers that this process in its essentials occurs in connection with ordinary chronic tuberculosis and that the exudative process is the destructive one. Etiologically considered, the process is probably due to the sudden access of a large number of bacilli.

Orth speaks of all attempts to reproduce the lesion as having failed or as being imperfect in that fibrinous exudation was not developed and productive lesions usually resulted.

Tendeloo (5) describes a case of acute tuberculous lobar pneumonia and discusses a case previously reported by Fraenkel and Troje (7). Tendeloo believed that his case arose by the discharge of tuberculous material from an old softened focus into a vein. He explains the formation of predominantly exudative lesions in the lungs and other organs, instead of the usual type of miliary tubercle, as being possibly due to the associated presence of necrotizing substances derived from the old focus. Fraenkel and Troje believed their case to be of bronchogenic origin.

In our experiments we believe that we have effectively reproduced this exudative type of tuberculosis of the lungs. This type of lesion may, in the light of our experiments, result from the sudden bronchogenic invasion of large numbers of virulent tubercle bacilli in a relatively resistant animal.

The large mononuclear cells so frequently encountered in the exudate seem to be brought there chiefly from outside.[1] As Orth found when studying human material, it is difficult here also, to exclude the possibility that similar cells may result from the desquamation of alveolar epithelium.

The tubercle bacillus alone, without the aid of secondary infection, is competent to produce a type of lesion which leads to necrosis of the bronchi, and by discharge of the necrotic material to cavity formation. As judged by our experiments the bronchi are less resistant to involvement in the necrosis than are the blood vessels or pleural surfaces.

The fact that by the method of bronchial insufflation of Lamar and Meltzer a characteristic tuberculous pneumonia may be produced makes it probable that the lobar pneumonias generally are of bronchogenic origin.

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[1] Since this study was completed, Evans, Winternitz, and Bowman (6), by the application of vital staining methods, have shown that certain cells which are of the same general type morphologically but which are probably of tissue origin (the histogenic wandering cell or pyrrol cell of Goldman) are active in the early stages of tubercle formation. As this work is still in progress, we have not attempted to apply these methods to the determination of the type of these cells. On general morphological grounds the mononuclear cells of this exudate resemble the large mononuclear cells of the blood and lymphatic organs more than the tissue cells with which they are concerned.

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EXPLANATION OF PLATE 101.

FIG. 1. Dog 31, twenty days after inoculation. Cavity showing communications with a bronchus and exposed blood vessels.

FIG. 2. Dog 15, twenty-four days after inoculation. Ramifying connecting cavity formation.

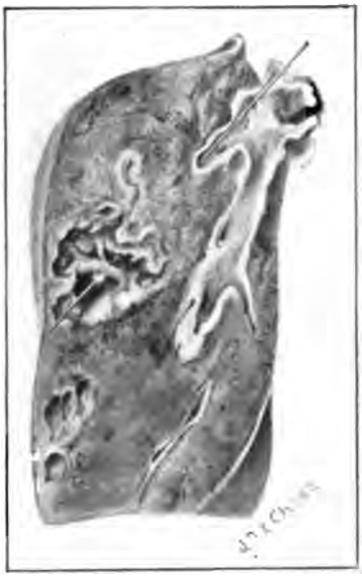

FIG. 1.

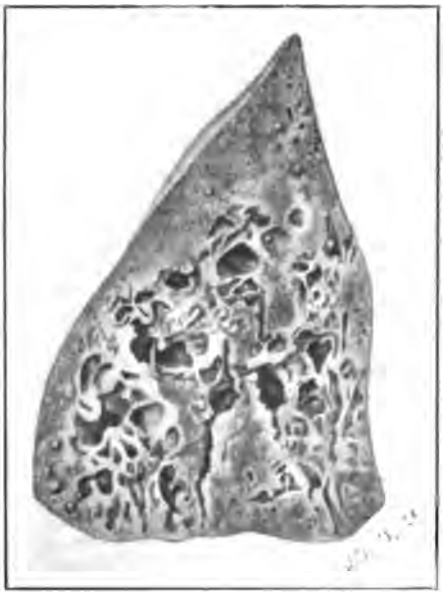

FIG. 2.

(**Lewis and Montgomery**: Pulmonary Tuberculosis in the Dog.)

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EXPERIMENTAL TUBERCULOSIS OF THE CORNEA.*[1]

BY PAUL A. LEWIS, M.D., AND CHARLES M. MONTGOMERY, M.D.

(*From the Henry Phipps Institute of the University of Pennsylvania, Philadelphia.*)

When an attempt is made to study the tissue reactions against the tubercle bacillus in either the normal or the immune animal, difficulties of a technical character are at once encountered. The final picture in an animal infected with tuberculosis is extremely complicated, and it is impossible to resolve it into its functional elements. Methods of examination during life are practically limited to such general conditions as changes in activity, body-weight, and temperature. The great help derived in the study of other infections from the investigation of changes in either serum or cells of the blood does not touch the problem.

In the belief that it would be of great advantage to be able to study a discrete tuberculous lesion which could at the same time be kept under constant observation without the necessity of resorting, in each experiment, to the tedious technical procedures involved in microscopic examination, we have undertaken a renewed study of experimental corneal tuberculosis.

The work is still in progress. This paper is intended to present primarily the technical phases of the subject, and to indicate briefly the limitations and possibilities of this line of experimentation. Secondarily, there will be presented some facts to show that the corneal lesion is susceptible of influence in an appreciable degree by both local and systemic measures and conditions.

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* Received for publication, June 11, 1914.

[1] The experiments here published were used as the basis of a paper read before the Lænnec Society of Johns Hopkins University in April, 1912. Extraneous circumstances have interfered with the prompt publication of the matter. In the meantime the experiments have for the most part been repeated on a large scale in connection with chemotherapeutic studies. The results of the later experiments conform in all essential respects to those here described.

The general features of the lesion of the cornea following inoculation with tubercle bacilli or tuberculous matter were described by Cohnheim and Salomonsen (1) in 1877. Their inoculations were made into the anterior chamber, and consequently their lesion did not develop in detail according to our description.

Other observers have used the corneal experiment to study microscopically the early development of the tubercle, but this is a matter with which we are not here immediately concerned.

Hänsell (2) in 1879 inoculated the cornea, conjunctiva, and anterior chamber with tuberculous matter. He described the corneal lesion in its essentials with accuracy, both in its gross and microscopic features.

Krusius (3) has presented interesting data on experimental tuberculosis of the various parts of the eye. He has developed the fact that the cornea is less susceptible to infection than the anterior chamber and the vitreous humor. It is more susceptible than the lens. Krusius states that the incubation period of the lesion in the cornea is inversely proportional to the dose of culture used. This author notes that in order to get consistent results it is important to use a culture of known virulence and rabbits of equal resistance (same weight, age, etc.). In a general way our results agree with those of Krusius entirely, although we have developed them and have considered the subject from an entirely different point of view. In one or two points there is an apparent contradiction between our results and his. He states that generalization does not occur from the eye lesion even when a culture of bovine type is used. He also found that the lesions showed frequently a distinct tendency to heal. Our animals when they have been kept for a sufficient length of time have always shown tubercles in the internal organs. In but few instances have the corneal lesions shown any definite tendency to heal. These differences indicate that we have used cultures of higher virulence than those employed by Krusius.

The observations on the use of iodin locally have been indicated by the clinical use of this substance more or less regularly since the time of Lugol for the purpose of influencing tuberculosis in one or another of its manifestations.

In using calcium lactate we have followed the observations of Chiari and Januschke (4) on the inhibitory influence of soluble calcium salts administered generally on simple inflammations.

Our observations on benzol have been made under the influence of the experimental work of Selling (5), in which the pronounced leucotoxic action of this substance was developed.

TECHNIQUE.

In all the experiments reported, we have used rabbits. The animals have varied in weight from 1,500 to 3,000 grams, have been of various colors, and purchased from various sources. They were of no especial breed. For most of the experiments we have used a culture of bovine type, isolated from cervical glands in 1907. The culture retains a high degree of virulence, as 0.01 of a milligram intravenously injected will kill a rabbit of 2,000 grams in from twenty to thirty days, with generalized tuberculosis. The culture was grown on glycerin agar, and the growth was used within fourteen days of the time of transfer. The culture was suspended in a salt solution to make a suspension as homogeneous as possible, and this was centrifuged at high speed for a short time to remove the macroscopic clumps. The suspensions varied in weight, but were, as a rule, made by suspending one glycerin agar tube in ten cubic centimeters of salt solution. The completed preparation was usually of sufficient density to be just completely opaque when contained in the ordinary twenty millimeter bacteriological test-tube.

The eyes before inoculation have been carefully anesthetized with cocain. When this is done, the injection can be made without restraining the animal in any way, and it gives no pain or discomfort. In the beginning we tried to fix the eye with a pair of forceps. We found later that the injection could be made equally well without it. The injury done by the fixation forceps frequently gave rise to secondary foci of infection which should be avoided. We have used a small record syringe, but we have found it better to use special needles that we have had made for the purpose. The most satisfactory are of iridoplatinum, of about gauge 26, and ground to a very short bevel, with a sharp point. The advantage of the platinum needle is that it retains a smooth surface free from rust, even after being sharpened repeatedly. This seems to be very important in making a successful injection. The ordinary steel needles can be used with success when they are new, but they cannot be used after sharpening or repeated boiling.

The injection is made by placing the point of the needle against the cornea in the position desired, holding the syringe in a plane parallel to the cornea, considered as a flat surface. The needle is then inserted by a succession of short, jerky pushes, in which only slightly more force is used than that exerted by allowing the weight of the syringe to bear on the needle point. By this means, the eye is rotated, and between each push is allowed to come back almost to its normal position. When the aperture of the needle is entirely covered by the corneal epithelium, pressure is put on the piston, and the suspension forced into the cornea. Considerable pressure is required. The fluid raises a small vesicle which is at once opaque.

We have not found it practicable to measure the amount of fluid injected, but a fairly uniform series of inoculations can be secured by watching the size of the opacity produced. We have had most uniform results when this measured about three or four millimeters in diameter.

It cannot be said that this technique is perfect. Occasionally, instead of raising a definite circumscribed vesicle, the fluid flows into the cornea along radiating lines, spreading widely from the point of puncture. In a certain number of instances the needle penetrated the anterior chamber. This accident, however, has grown much less frequent as we have gained experience. Moreover, it seems probable that the ultimate result varies, to a certain extent, according to whether the injection mass remains localized close beneath the corneal epithelium, or flows more deeply into the tissue. When the larger amounts suggested are injected, there seems to be less variation due to this factor. In certain instances, instead of injecting the material we have made the inoculation simply by pricking the cornea with the needle wet with the culture. The results of this procedure will be explained later.

In our examinations made subsequent to inoculation we have confined ourselves to the use of oblique illumination. We have found it advantageous to use artificial light because of the greater constancy, and have adopted a 40-watt Tungsten lamp with a ground glass bulb held about sixteen inches distant from the eye. With this we have used a small hand lens.[2]

We have, of course, made careful notes of the development of the lesion, but have found that frequently we save much time and secure, on the whole, more useful records by charting the conditions from day to day.

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[2] Dr. Thomas B. Holloway has recently been over the methods of examination of the eye with us and has pointed out the possible usefulness of the corneal loop and the ophthalmoscope. We have not used these instruments extensively, so far as the results at present recorded are concerned, but they will probably add to the accuracy of our examinations in the future. It is likely that the use of these more accurate methods of examination would modify our statements only as they concern the time of appearance of the earliest vascularization of the cornea.

DEVELOPMENT OF THE CORNEAL LESION.

The Effect of Large Doses of Tubercle Bacilli.—When a heavy suspension of tubercle bacilli is injected into the cornea in such a way as to make a distinctly circumscribed infiltrated area of three to four millimeters in diameter, the first result, as has been said, is a circumscribed opacity, which probably marks fairly well the limits of the infiltration. At the end of twenty-four hours this opacity has usually almost disappeared. At this period one is able by careful examination to see the defect in the cornea that marks the point where the needle penetrated, and extending from this defect a very short way into the cornea is a very fine, whitish or brownish white line. At this period, the sclera and bulbar conjunctiva will have their normal appearance, and there will be no evidence of any irritation of the eye. In from three to seven days, depending on various factors, there is a noticeable change. A small increasing opacity of grayish white color develops at the point of inoculation on the cornea, and the conjunctiva of the bulb becomes increasingly injected from day to day. On the seventh day, for the average, the opacity at the point of inoculation has a diameter of about one millimeter. The relation of the size and rapidity of growth of the opacity to the appearance and development of the injection of the bulbar conjunctiva is not perfectly regular, although it is fairly so. As a rule, the conjunctival congestion begins at about the time that the first visible increase in the exudate at the inoculation point shows itself. After several more days, the conjunctival congestion having in the meantime become very intense, loops of newly formed capillaries appear in the cornea, pushing out from the margin towards the inoculation point, and the exudate at the inoculation point continues to increase. The loops of vessels extend further and further into the cornea, until finally they come into contact with the exudate. The congestion of the bulbar conjunctiva becomes complicated by congestion of the conjunctiva of the lids. The lids swell and there is more or less of an increased secretion, which is at times white, at times yellowish. It is usually sufficiently fluid to remove itself spontaneously, but occasionally it becomes sticky and glues the lids together. This does not often occur before the third week after inoculation. At about the time that the corneal vascularization or pannus comes into contact with the exudate at the point of inoculation, the corneal epithelium over the exudate usually breaks through leaving an open ulcer.

The formation of the pannus takes place in a regular way. The first vessels formed are capillaries and an advancing margin is maintained as a capillary zone. Behind the advancing margin there is a tendency for the pannus to thicken to a definitely raised rather pale zone of granulation tissue. Between this area and the corneoscleral junction the vessels are gradually reduced in number and increased in size until there are formed several main trunks of supply to the more central lesion. These supply trunks run through a cornea which has become partially clear again. In the later stages, with the advance of the exudate and the invasion of the pannus by it, the peripheral clear zone again becomes obscured and filled with granulation tissue.

When large doses are used, the pannus never tends to invade, in any marked degree, the mass of exudation. On the contrary, the exudate gradually extends and infiltrates the pannus. Most of our experiments have terminated at this point. The exceptional instances which have been kept longer under observation will be commented on in later paragraphs in connection with special points. With the large dose in the untreated eye, the vascularization of the cornea usually begins between the eighth and twelfth days.

The Effect of Small Doses of Tubercle Bacilli.—With the results following large doses, we have contrasted the effects of a minimal inoculation. They have been obtained, as before stated, by simply wetting the needle with the culture and pricking the cornea. In making the inoculation in this way it is essential that the epithelium be pierced. If the epithelium be merely superficially scratched, the inoculation is not effective. With the small dose, there come into play the same factors that have been described for the large dose. Very essential differences, however, are to be noted. The rate of progress of the lesion is much less uniform. The ultimate appearance of the lesion, in the majority of cases, is much the same, but in details of the first importance there are variations. It is especially by the use of this method of inoculation that one can determine differences in individual resistance of the animal. In old rabbits the changes occur much more slowly than in young rabbits. It has occasionally happened, in using this method on old rabbits, that the pannus has completely infiltrated the mass of exudation at the point of inoculation. In the young rabbit it has happened conversely that the pannus has not only been invaded by the mass of exudation, but that it has actually been involved extensively in the ulcer, and has been almost completely eaten away. Various intermediate conditions are encountered.

INFLUENCE OF VIRULENCE OF CULTURE.

We have not so far studied extensively the action of different cultures on the cornea. However, some inoculations were made with cultures of human type which are, of course, non-virulent for rabbits. The large dose before described produced the same end result that the large dose of the virulent culture did. Smaller doses or doses of less virulent human culture produce a lesion which is smaller and which shows a great tendency to heal spontaneously. The lesion in its development follows the general course of that described for the bovine type culture with some differences which serve to place it between the bovine lesion and that about to be described for the non-virulent acid-fast bacilli. The immediate reaction to the human type is somewhat more rapid as a rule. The blood vessels begin to form more quickly but the progress of the lesion is less rapid. While the virulent culture generalizes from the eye as a focus, the human type of culture does not generalize. We hope later to develop this phase of the subject.

CONSEQUENCES OF PERFORATION.

If the cornea is perforated at the time of inoculation or, as has often happened in our series, the ulceration of the cornea occurs internally as well as externally, an infection of the anterior chamber results. The consequences of such infection have been sufficiently described by others. We wish to note, however, one or two points which are of interest by contrast with the pure corneal infection, and which chiefly concern the pannus. The typical pannus, which is formed as a result of the infection of the cornea, begins at a single point on the corneoscleral junction, extending centrally and broadening out from this point. If the injection is so placed that it is somewhat above central, the pannus always begins at the upper margin of the cornea. When the lesion has become quite extensive, a second pannus may appear starting from below. Placing the injection forward or back of central throws the point of beginning of the pannus either somewhat forward or back, as the case may be. It is an interesting point that when the injection is either precisely central or slightly below central, the first pannus will still form above. From the moment that the cornea perforates internally, however, a circular pannus begins to form. We have controlled this point by injecting the anterior chamber in such a way that the cornea was not injured; that is, by passing the needle through the sclera from behind. Here the pannus is also circular, and no difference between the upper and lower margins can be noted. These differences presumably depend on the circulatory channels in the cornea, but we have at present no more precise explanation for them.

THE EFFECT OF KILLED CULTURES OF THE TUBERCLE BACILLUS.

When we had proceeded with this work for some way, we were led to consider how much of the effect produced by the inoculation was specific for the tubercle bacillus, and how much might depend on the non-specific factors. Before trying anything more remote, we used the same culture killed by heating for one half hour to 60° C. When such a killed culture is injected in about the quantity of a large dose of living culture, the first effect is the same. At the end of twenty-four hours a difference appears, in that the bulbar conjunctiva is usually pronouncedly injected, and the eye appears to be definitely more irritated than by the injection of the living culture. The inoculation point becomes marked out by an exudate in about the same way as with the living culture, but this exudate seldom reaches more than pinhead size. On the fourth or fifth day, as contrasted with the eighth to the twelfth day for the living culture, loops of vessels appear in the cornea. They appear at the situation favored by the vessels appearing in response to the living culture. They extend very rapidly into the cornea as a thin leash which on the sixth or the seventh day reaches nearly to the point of inoculation. The base of the leash never broadens; it is usually about three to five millimeters in width. From the seventh day on these vessels seem rapidly to disappear. By the tenth day nothing more of them can be seen in the cornea by our methods of examination. No permanent pannus is formed. The exudate at the inoculation site may be entirely reabsorbed, or may persist for months as a pinhead-sized scar. The vessels do not, however, really disappear, at least not within a period of two months. They cease to functionate. This can be shown by making a fresh inoculation with either dead or living cultures near the old scar. Under these circumstances at the time when the congestion of the sclera becomes well marked, the old corneal vessels suddenly fill and the new formation of vessels in consequence of the second inoculation takes place from the end of the old leash.

For obvious reasons we have compared the lesions so far described with the corneal lesion produced by other bacteria. The strains of *Staphylococcus aureus* and *Bacillus typhosus* used, when inoculated on the cornea near its center, produce a rapid local exudation. There is, however, no tendency to vascularize the cornea and the exudate finally resolves more or less completely leaving a relatively small opacity at the inoculation site.

The acid-fast bacteria other than *Bacillus tuberculosis* give a lesion which in severity and time relation develops much more like the lesion caused by the dead tubercle bacilli than by the living. The exudation is small, the vascularization commences early, and the vessels cease to functionate after a short time. The lesion usually resolves, leaving only a small scar. We have used in this connection the bacillus of timothy, the butter bacillus of Grassberger, Korn's grass bacillus D., the bacilli of frog and fish tuberculosis, an old isolation of the bacillus of avian tuberculosis, and the chromogenic *Bacillus lepræ* of Duval. The last of these cultures has sometimes shown a more progressive and persistent lesion than the others. The difference between *Staphylococcus aureus* and *Bacillus typhosus* on the one hand, and *Bacillus tuberculosis* and the acid-fast bacteria on the other, in capacity to stimulate the formation of vascular tissue in the cornea is striking. It is, however, a purely quantitative difference or one which is not manifest under more general conditions. This is shown when *Bacillus typhosus* or *Staphylococcus aureus* are inoculated, avoiding the cornea, into the anterior chamber through the sclera. As a consequence of the anterior chamber infection a vascular, circular pannus quickly forms on the cornea.

As described, the corneal lesion due to the inoculation with the tubercle bacillus proceeds in an orderly fashion through certain clearly defined stages and presents in some degree an opportunity for an analysis of the processes involved. Certain experiments were now undertaken to determine whether or not the course of the lesion could be influenced by the local and general administration of various substances. As we hope to develop this phase of the subject in greater detail in the future we shall now merely present our results in outline in so far as they show that the lesion can be modified.

Iodin, Locally Applied as Lugol's Solution.—If the conjunctival sac be washed daily with Lugol's solution the early development of the lesion is in no way influenced. In many instances the pannus when well formed thickens to an unusual degree. The secondary thinning out of the vascular tissue near the corneoscleral margin does not take place. In order to attain this effect the concentration of the iodin in the solution and the duration of the exposure must be sufficient to produce a distinct inflammation when applied to the healthy control eye. The effect may be in large measure an additive one. We have never seen the pannus invade the central exudate under the influence of iodin.

Tuberculin.—Koch's old tuberculin given intravenously in large or small doses or instilled into the eye is without effect on the early development of the lesion. We have not tried its effect later when panophthalmia exists, and our results in no way contradict those of previous observers who have made out a favorable influence from the treatment of experimental and clinical tuberculosis of the eye with this preparation.

Calcium Lactate.—Calcium lactate administered intravenously or subcutaneously in doses sufficient to intoxicate the animal severely is able to inhibit the corneal process in considerable degree. The central exudation perhaps increases more slowly than usual, although this is not perfectly clear. The vascularization of the cornea is somewhat delayed in point of time and proceeds more slowly and much less vigorously than usual.

Benzol.—The subcutaneous administration of benzol in olive oil to the point of severe intoxication decreases the amount of exudation to the inoculation point and causes the vascularization of the cornea to develop slowly and feebly. This experiment like that with calcium lactate cannot be carried to a satisfactory conclusion because it is necessary to give the substance in doses certainly although slowly fatal in order to get demonstrable results. The control blood counts have shown that only in those cases in which the leucocytes were reduced very low has there been an appreciable influence on the development of the lesion.

Intercurrent Disease.—In several instances we have inoculated recently purchased, supposedly normal animals which in the first few days developed an acute illness followed by a period of extreme emaciation. In these animals the development of the corneal lesion was also slow and without vigor. The exudation at the inoculation point was inhibited and until this was well developed there was no vascularization of the cornea.

DISCUSSION.

The foregoing experiments taken in a general sense can hardly be said to differ radically from certain of those previously performed by others. Moreover, when we consider them in detail and attempt to formulate their meaning it is often difficult to be sure that what we have learned is not already fairly well understood by those closely familiar with the pathology of tuberculosis. In spite of a degree of uncertainty as to the final value of such considerations, it is our purpose to state in our own language the point of view at which we have arrived by way of this work and to indicate some of the problems which are defined by it.

Tuberculosis is classed by systematic pathologists as an infectious granuloma. The justice of this classification is emphasized by these experiments. The corneal lesion consists of a mass of granulation tissue the various elements of which are present in variable proportions at different stages in the development of the disease. The experiments recorded in which the action of *Bacillus typhosus* or *Staphylococcus aureus* is contrasted with that of the tubercle bacillus on the cornea indicate that the latter much more readily gives rise to the formation of blood vessels. This power of stimulating blood vessel formation is also possessed by other acid-fast bacilli. As shown by the results of anterior chamber inoculation, however, the difference is one of quantity rather than of quality. *Bacillus typhosus* and the pyogenic cocci under proper conditions may likewise stimulate blood vessel formation. As a large exudative lesion produced on the cornea with *Bacillus typhosus* may fail to give rise to the new formation of capillaries, while even a minimal lesion with dead tubercle bacilli or with non-virulent acid-fast organisms of other kinds leads to their rapid formation, we are probably justified in believing that the difference is a large one and perhaps of vital importance in the development of the disease. The corneal lesion develops in an orderly way. The irritation due to the injection is recovered from, is followed by a latent or incubation period, and this in turn is followed by the development of a local exudation. Not until the exudate has become definite does the formation of blood vessels begin. In experiments such as those with benzol and calcium lactate in which the primary exudation is limited or suppressed, the blood vessels fail to develop or develop very feebly. Presumably if it were possible to prevent the exudation entirely, the vessels would never develop. Expressed in terms of the prevention of the disease, these results are of little significance. While it is possible to say in these terms that the development of a tuberculous lesion has been definitely delayed by these agencies, yet it has been by methods that are so severe in their general effects that even the experiments can hardly be continued to a satisfactory conclusion.

From another point of view, however, the matter has interest. In the well developed corneal lesion the tubercle bacillus is present in enormous numbers. Several of these inhibitive experiments have lasted from two to three weeks, and in this time the cultures we have used on culture medium attain a large growth. If in this time there was a great growth of the organism in the transparent cornea it might be expected to become visible; or if the bacteria did not become visible as a colony, the cornea should develop a local defect. As a matter of fact no visible change occurs in the absence of exudation and it seems to be a fair conclusion that we are dealing with a true condition of latency, one in which the bacillus grows little if at all, and in which the tissues are practically unchanged. Stated in another way, the conclusion is indicated that there is nothing in the fixed tissues of the cornea to provide for food for the bacillus and little or nothing about the living tubercle bacillus which does injury to these tissues. With the coming of the cellular exudate the case is entirely different. The products of cellular degeneration furnish food for the bacillus and the fixed tissues are attacked either by the products of the growth of the bacillus in this pabulum or by the products of cellular activity or cellular degeneration. From this heterogeneous combination also, substances are set free which give a stimulus for blood vessel formation and doubtless for the proliferation of other fixed tissue cells.

If this reasoning is in any measure correct, and we believe that it is largely so, we are forced to agree with those who have held that tuberculosis is primarily an exudative inflammation and secondarily proliferative in its character. More than that, we are led to the belief that the cellular exudate, protective though it may be in purpose, is defective and is destructive in its actual influence. Even the phagocytic activity of the cells of such an exudate may probably serve to distribute living bacilli and thus spread the disease to fresh areas.

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THE FUNCTION OF THE SPLEEN IN THE EXPERIMENTAL INFECTION OF ALBINO MICE WITH BACILLUS TUBERCULOSIS.*

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Experiments were begun in this laboratory three years ago to test the susceptibility of white rats and white mice to infection with *Bacillus tuberculosis*. It was expected that the animals would show a high degree of resistance to the infection, but it was hoped that they might react with such regularity as to make them available for testing various therapeutic measures. This expectation was in no way fulfilled. It developed that the animals were, on the whole, susceptible to infection, but that there was much irregularity in the reaction of individual animals.

The first experiments were made with rats. It was noted that a constant lesion in these animals was a great increase in the size of the spleen, which occurred whenever the animals survived two weeks or more. It was also noted that in several instances where the animals died in the second week after inoculation the spleen was small and extremely hemorrhagic. It seemed not impossible from a consideration of these facts that the spleen might be an important factor in the resistance of the animal to the infection, and that irregularity in the reaction of this organ might account in considerable degree for the irregularity of reaction of the animal as a whole. The same general facts were observed in a repetition of the experiments in mice.

A number of mice were splenectomized and later tested for their resistance, in comparison with intact controls. Contrary to expectation the splenectomized animals were found to have more than

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normal resistance. In fact a number of animals without spleen have survived for months after inoculation with amounts quickly fatal to normal animals. In this paper we shall present the data on which the foregoing statements are based, with such observations as we have so far made that bear upon the cause of the increased resistance.

We are aware of no literature bearing on the main points at issue although the virulence of the tubercle bacillus for rats and mice, and the pathological anatomy of experimental tuberculosis in these animals, has been the subject of considerable study.[1]

The removal of the spleen was carried out under ether anesthesia. After etherization the mice were tied out on a frog board. The abdominal region was shaved and the spleen delivered through a suitable incision. The main blood vessels were ligated in the omentum, and the organ was then cut off. In closing the laparotomy wound the muscles and skin were separately sutured with fine silk. The animals were kept for a number of hours after operation in a warm place, free from draught. The operation was well borne; a small proportion of the animals died, either under ether or, within a few days, from hemorrhage or peritonitis. Animals surviving beyond the first week seemed to be in good health. The inoculations have never been made in less than two weeks after operation, and have usually been done in the third week.

The cultures used for inoculation were of bovine type. Culture bovine C was isolated in 1912 from a case of spontaneous bovine tuberculosis. This culture is somewhat more virulent for mice than culture R_8, also of bovine type, isolated in 1911 from a human case of cervical adenitis.

The observations are presented in the following tables.

Table I illustrates the constancy and also the degree of enlargement of the spleen when rats are infected with fatal doses of tubercle bacilli.

Table II gives the results of all the inoculations made into normal mice with one, two, and five milligrams of culture bovine C. The culture has never failed to kill in these doses. The maxi-

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[1] The literature is reviewed by Goldmann, E., Neue Untersuchungen über die äussere und innere Sekretion, Tübingen, 1912, 52.

TABLE I.

Relation of Spleen Weight to Body Weight in Rats.

Normal rats.		Tuberculous rats.[2]	
Body weight.	Spleen weight.	Body weight.	Spleen weight.
123 gm.	0.26 gm.	140 gm.	1.46 gm.
135 gm.	0.43 gm.	150 gm.	1.15 gm.
130 gm.	0.37 gm.	115 gm.	1.30 gm.
129 gm.	0.71 gm.	135 gm.	2.08 gm.
150 gm.	0.42 gm.	110 gm.	2.01 gm.
125 gm.	0.51 gm.	130 gm.	2.05 gm.
		115 gm.	1.60 gm.
		120 gm.	2.20 gm.
		125 gm.	1.01 gm.
		145 gm.	0.63 gm.
Average 132 gm.	0.45 gm.	128.5 gm.	1.57 gm.
Second Series. Average of Six Rats.			
70.6 gm.	0.20 gm.	Average weight lost.............. 8.3 gm.	

TABLE II.

Normal Mice. Culture Bovine C.

Dose.	Lived.	Exudate.	Spleen.	Liver.	Heart blood.	Lung.	Kidney.
1 mg.	14 dys.	+	+	—	—	—	—
1 mg.	5 dys.	+	+	—	—	—	—
1 mg.	13 dys.	+	+	+	o	+	+
1 mg.	13 dys.	+	+	+	+	+	+
1 mg.	13 dys.	+	+	+	o	+	+
1 mg.	14 dys	++	+	+	+	+	+
1 mg.	14 dys.	++	+	+	+	+	+
1 mg.	10 dys.	++	+	+	o	+	+
1 mg.	19 dys.	++	+	+	o	+	+
1 mg.	19 dys.	++	++	+	+	+	+
2 mg.	10 dys.	+	+	+	o	o	o
2 mg.	13 dys.	+	+	+	o	+	o
2 mg.	14 dys.	+	+	+	o	+	+
2 mg.	20 dys.	+	++	++	+	+	+
2 mg.	20 dys.	++	++	+	+	++	+
2 mg.	33* dys.	++	+++	+	+	++	+
5 mg.	13 dys.	++	+	+	o	+	+
5 mg.	13 dys.	+	+	+	+	+	+
5 mg.	14 dys.	++	+	+	o	+	+
5 mg.	14 dys.	++	+	+	+	+	+
5 mg.	14 dys.	++	+	+	+	+	+

++ = many tubercle bacilli; + = few tubercle bacilli; o = no tubercle bacilli; — = examination for tubercle bacilli not made; * = nodules in lungs and heart muscle.

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[2] The tuberculous animals were killed twelve days after the intraperitoneal inoculation of 10 mg. of the culture.

mum length of life was thirty-three days. At autopsy the animals frequently showed a small amount of thick yellow exudate in the omentum. The spleen was greatly enlarged. The one mouse that lived over thirty days showed numerous miliary nodules in the lungs. The nodules were softer and showed less organization than tuberculous masses of the same relative size as they are found in other species of experimental animals. The organs and frequently even the heart blood contained enormous numbers of tubercle bacilli.

TABLE III.

Splenectomized Mice. Culture Bovine C.

Mouse No.	Dose.	Lived.	Peritoneal dry exudate.	Peritoneal fluid.	Liver.	Kidney.	Lung.	Heart blood.	Remarks.
1	1 mg.	5 dys.	o	+	o	o	o	o	
2	1 mg.	18 dys.	o	o	o	o	o	o	
3	1 mg.	32 dys.	o	o	o	o	o	o	
4	1 mg.	34 dys.	+	—	+	o	—		
5	1 mg.	37 dys.	o	o	o	o	o	o	
6	1 mg.								Still living.
7	1 mg.								Still living.
8	1 mg.								Still living.
9	5 mg.	2 dys.	o	+	o	o	o	o	
10	5 mg.	29 dys.	+	—	+	o	+	+	Nodules in lungs and heart.
11	5 mg.	32 dys.	+	—	+	o	+	o	Nodules in lungs.
12	5 mg.	32 dys.	+	—	+	+	+	o	Nodules in lungs and liver.
13	5 mg.								Still living.

+ = few tubercle bacilli; o = no tubercle bacilli.

Table III gives the results of the first series of inoculations of splenectomized mice. It will be noted that two of the mice died within the first few days after inoculation. It is unlikely that the tubercle bacilli inoculated were responsible for the deaths. However, even if we include these presumably accidental losses, it is seen that the length of life in the splenectomized mice is much longer on the average than in the case of the normal mice, as shown in table II. Moreover, at the present writing (October, 1913), more than six months after inoculation, four of the animals are still alive and seem to be in perfect health. The increase of resistance, as brought out in this series, has been repeatedly demonstrated in similar experiments or in slight modifications of them. It is of interest that these splenectomized mice, dying after the thirtieth day, show the same formation of nodules in the lungs that is found in the occasional normal mouse, surviving for an equal time. The bearing of this fact will be considered later.

It will further be noted that, as shown in tables II and III, the presence and distribution of the tubercle bacillus in the splenectomized animals that died was much more limited than in the intact animals. This suggested the possibility that in the splenectomized animals there might be a rapid destruction of tubercle bacilli which did not prevail in the intact animal. With this idea in mind we have studied the distribution of the tubercle bacillus in the first hours after intraperitoneal inoculation in splenectomized as compared with normal animals. The result of this study has been to show that in the normal animal, tubercle bacilli appear in the substance of the spleen, in the portal vein, in the liver, in the bile, and in the lumen of the small intestine within four hours after inoculation in sufficient numbers to be found readily. In splenectomized mice, on the contrary, we have never observed them outside the peritoneal cavity in less than seven days.

Within the peritoneal cavity there is no evidence of rapid lysis or increased phagocytosis. The splenectomized mice show more fluid exudate than the controls, but the significance of this fact is by no means apparent. It would seem, therefore, that the removal of the spleen has interrupted a path by which the tubercle bacillus is excreted from the normal mouse with some rapidity. These observations tend to emphasize the increased resistance brought about by the splenectomy, but in no way explain the cause of it.

In searching for an explanation of the increase of resistance, several possibilities demand consideration. In the first place it might be considered that the spleen formed a most favorable focus of infection as compared to the other organs of the body, and that with the removal of the organ much of the available food stuff is removed. Direct evidence as to the value to be assigned to the organ on the basis of these considerations is difficult to obtain.

The facts presented in regard to the limitation of the distribution of the bacilli in the splenectomized mice suggest that perhaps the chief effect of the operation is to convert the general infection into a local one by interrupting mechanically a path of transmission. In order to test this supposition we have infected comparative series of animals in the pleural cavities. The results of this experiment as presented in table IV show that the increased resistance also prevails under these conditions. The infection tends to remain localized in the pleural cavities in this case.

TABLE IV.

Controls. Culture R_3. Intrapleural Inoculation.

Mouse No.	Dose.	Lived.	Pleural fluid.	Peritoneal exudate.	Spleen.	Liver.	Kidney.	Heart.	Lung.	Remarks.
1	1 mg.	24 dys.	+	+	+	+	+	o	++	Killed. Nodules in lungs.
2	1 mg.	27 dys.	++	+	+	+	+	o	++	Killed.
3	1 mg.	36 dys.	++	++	+	+	+	+	+	Pleural adhesions. Nodules in lungs.
4	1 mg.	37 dys.	++	++	+	+	+	+	+	Nodules in diaphragm. Adhesions of pleura.
5	1 mg.	39 dys	+++	+	++	++	++	+	++	Nodules in mediastinum.
6	1 mg.	49 dys.	++	+	++	++	++	o	++	
7	1 mg.	49 dys.	+	+	++	++	++	o	++	Nodules in pleura.
8	1 mg.	49 dys.	++	+	++	+	++	+	+	Nodules in diaphragm.
9	1 mg.	61 dys.	++	+	++	+	+	+	++	Nodules in lung and heart.
10	1 mg.	61 dys.	++	+	++	+	+	o	++	Nodules in right axillary region surrounding a blood vessel.

Splenectomized Mice. Culture R_3. Intrapleural Inoculation.

Mouse No.	Dose.	Lived.	Pleural fluid.	Peritoneal exudate.	Spleen.	Liver.	Kidney.	Heart.	Lung.	Remarks.
11	1 mg.	25 dys.	++	o		o	o	o	+	Killed.
12	1 mg.	27 dys.	+	+		o	o	o	+	
13	1 mg.	48 dys.	++	o		o	o	o	+	Killed. Few nodules in lung.
14	1 mg.	70 dys.	+	o		o	o	o	++	
15	1 mg.	70 dys.	++	o		o	o	o	++	Few nodules in lung.
16	1 mg.	125 dys.	++	o		o	+	+	++	Many nodules in lung.
17	1 mg.	125 dys.	+	o		o	o	o	++	
18	1 mg.	133 dys.	++	+		o	o	o	+	Nodules in lung.
19	1 mg.	Living								
20	1 mg.	Living								

We are, therefore, forced to the supposition that following the removal of the spleen there is a general physiological effect which increases resistance. It has been mentioned in commenting on the results presented in table III that the mice that die after several weeks in the splenectomized series show the formation of gross nodular lesions comparable to those seen in the occasional normal mouse which survives for an unusual period. It is also notable that in the peritoneal and pleural cavities there is a plastic exudate similar to that found in the intact animals. This plastic exudate is accompanied by more fluid in the case of the splenectomized animal, whether the infection is intrapleural or intraperitoneal, but this does not furnish an obvious clue to the cause of the changed resistance.

The character of the various exudates found in the splenectomized series of animals seems to indicate that the removal of the organ does not radically change what we may call the capacity for exudation possessed by the body. The infection in the animals without spleen tends to remain localized. Experiments in progress may, we hope, show on what this limitation of distribution depends.

One control experiment should be mentioned. It is a well known fact in clinical medicine that tuberculous peritonitis is often greatly benefited and sometimes apparently cured by laparotomy without continuous drainage. As a comparable operation we have therefore removed one kidney from a number of mice by transperitoneal operation. When subsequently infected with tubercle bacilli the nephrectomized mice have reacted as do normal animals.

The change of reaction that is produced in mice by the removal of the spleen is one of the few striking instances of an increased resistance to an experimental infection with *Bacillus tuberculosis.* It would be of great importance if it should be proven that the resistance of other species of animals could be similarly altered. Experiments on guinea pigs and dogs to test this point have so far failed to bring out any change in resistance.

SUMMARY.

Infection of rats and mice with *Bacillus tuberculosis* (bovine type) develops a splenic tumor as a typical lesion.

Removal of the spleen from mice (albino) greatly increases their resistance to the infection. This increased resistance cannot

be explained at present. The infection in the splenectomized mice tends to remain localized as contrasted with an almost septicemic type of disease which is usual in the normal animal. The animals of each group that live more than thirty days are apt to present typical exudative lesions. The removal of the spleen does not therefore grossly change what may be called the capacity of the body for exudation.

THE FUNCTION OF THE SPLEEN IN THE EXPERIMENTAL INFECTION OF ALBINO MICE WITH BACILLUS TUBERCULOSIS.

[Reprinted from the JOURNAL OF EXPERIMENTAL MEDICINE, Vol. XXI, No. 1, 1915.]

THE FUNCTION OF THE SPLEEN IN THE EXPERIMENTAL INFECTION OF ALBINO MICE WITH BACILLUS TUBERCULOSIS.

SECOND PAPER.*

BY PAUL A. LEWIS, M.D., AND ARTHUR GEORGES MARGOT.

(From the Henry Phipps Institute of the University of Pennsylvania, Philadelphia.)

In a previous paper[1] we presented experiments showing that splenectomized mice are definitely more resistant than intact mice to experimental infection with the tubercle bacillus of bovine type. We have continued our work in the hope of arriving eventually at some adequate explanation of this increase in the resistance of the animal. Our more recent results seem to have some measure of general interest, although they have by no means served to solve the problem under consideration.

Before proceeding to the immediate subject of this paper, some comment on the matter contained in our first paper is necessary. The increase in resistance shown by the splenectomized mice, while unmistakable, has proved to be of a relative character rather than an absolute immunity. In table III of that paper four mice are marked as still living in October, 1913. As regards animals 6 and 13 the table is erroneous. These mice died 120 and 127 days, respectively, after inoculation.

No. 7 died in 306 days, and No. 8 in 314 days. In table IV of our previous paper animals 19 and 20 are marked "still living." These animals died 158 and 164 days after inoculation. All these mice had large numbers of tubercle bacilli in their organs, and there is no reason to doubt that they died as the result of this infection. Moreover, experiments which it is hardly necessary to present in detail have shown that in mice inoculated more than six months after splenectomy the resistance has diminished again to normal or nearly so.

In these animals, when infected for some time with the tubercle bacillus, we have usually found an accessory or perhaps, more properly, an hyperplastic accessory spleen, 1 or 2 mm. in diameter. We have considered it possible that this splenic tissue might be responsible for the loss of resistance occurring thus

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* Received for publication, October 31, 1914.

[1] Lewis, P. A., and Margot, A. G., The Function of the Spleen in Experimental Infection of Albino Mice with *Bacillus tuberculosis*, *Jour. Exper. Med.*, 1914, xix, 187.

spontaneously after some months. With this in mind we have reopened a number of uninoculated mice several months after splenectomy. In these animals we have been unable to find gross evidence of splenic tissue, and it seems probable that these small organs only become evident when rendered hyperplastic by the infection. What influence such subvisible splenic tissue may have on the physiological condition of the animal is problematical.

In a recent paper Murphy and Ellis[2] report experiments in confirmation of our observation of an increase in resistance after splenectomy. Studying mainly the changes in the lymphocytes of the blood in splenectomized and intact animals, with and without exposure to the X-ray, Murphy and Ellis are led to the belief that splenectomy increases resistance by causing an increase in lymphocytes. We have no data bearing on this interesting conclusion.

For the purpose of the present paper, therefore, we use as a point of departure the fact that mice after the removal of the spleen develop in the course of several weeks a well marked although transient increase in resistance to infection with *Bacillus tuberculosis.*

The present series of experiments were made to find out whether the function of the spleen could be wholly or partly replaced by feeding fresh sheep and mouse spleen to splenectomized mice infected with the tubercle bacillus.

In the present experiments the culture used, Bovine C, is one of those previously employed. The methods of splenectomy and infection are those outlined in our previous paper. It should be stated that the usual food of our mice is a mixture of stale bread and oats soaked in water. The animals have been kept in museum jars allowing six by eight inches of floor space. No more than six mice are kept in one jar. The jars are plentifully supplied with fresh wood shavings. The animals are changed at least three times a week to freshly scalded jars. In hot weather or when fresh meat has been fed in the jars this change has been made daily. The following tables (experiments I and II) present our more recent results.

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[2] Murphy, Jas. B., and Ellis, A. W. M., Experiments on the Rôle of Lymphoid Tissue in the Resistance to Experimental Tuberculosis in Mice, *Jour. Exper. Med.,* 1914, xx, 397.

The tables of Murphy and Ellis show only the average duration of life, and are not particularly convincing. Dr. Murphy has informed us that some of the splenectomized animals lived much longer than any of the controls. It will be noted that in all our tables certain animals are recorded which lived but a few days. These seem to occur without relation to the nature of the experiment. If they are included they greatly disturb the averages except when the groups are very large. In the absence of any definite basis for excluding such animals from consideration, we feel that it is best for the present to discard the average and present the length of life of each individual.

EXPERIMENT I.

Intraperitoneal Infection.

Group.	Mice.	Amount of culture.	Subsequent treatment.	Days lived.
I	Intact	1 mg.	None	18, 20, 24, 29.
II	Intact	1 mg.	Fed	16, 20, 29, 29.
III	Splenectomized	1 mg.	None	3, 40, 58, 59.
IV	Splenectomized	1 mg.	Fed	19, 28, 30, 34.
V	Intact	5 mg.	None	17, 20, 20, 26.
VI	Intact	5 mg.	Fed	20, 20, 28, 29.
VII	Splenectomized	5 mg.	None	40, 40, 46, 48.
VIII	Splenectomized	5 mg.	Fed	2, 2, 28, 28.

In this experiment the groups marked under "subsequent treatment" as "fed" received sheep spleen daily. The fresh spleen cut in small pieces was given to them early in the day before they had had other food and was left for several hours so that the animals ate their fill. The reaction of the animals to this method of feeding will be commented on at length in later paragraphs.

EXPERIMENT II.

Intraperitoneal Infection.

Mice.	Amount of culture.	Subsequent treatment.	Days lived.
Intact.........	1 mg.	None	28, 29, 30, 31, 32, 33, 37, 38.
Splenectomized .	1 mg.	Fed fresh sheep muscle	37, 38, 43, 47, 50, 54, 79, 87.
Splenectomized .	1 mg.	Fed sheep spleen	4, 30, 32, 37, 37, 37, 38, 41.
Splenectomized .	1 mg.	Fed mouse spleen	4, 30, 31, 32, 32, 32, 33, 37.

In this experiment the group which was fed with muscle received all that they would eat each day before being offered other food. Those fed with sheep and mouse spleen received an unmeasured amount, but a much smaller one than that available in experiment I. Before receiving other food each mouse in these groups was placed in a separate jar and given a bit of spleen roughly equivalent to one fourth of the usual mouse spleen. The pieces did not exceed the bulk of a small pea.

These experiments have produced additional evidence that splenectomy increases the resistance of mice to infection with the tubercle bacillus. The extreme prolongation of life noted in the experiments reported in the previous paper has not occurred in the present series, but the differences developed in experiment I between the time of survival of groups III and VII and their respective control groups I and V are none the less striking.

It is evident also from the results of experiment I, on comparing group I with II and group V with VI, that the feeding of fresh sheep spleen to intact mice has no influence on the course of their infection. Groups IV and VIII, on the other hand, show that feeding fresh sheep spleen to splenectomized mice leads to the loss of the resistance afforded by the removal of the spleen. Experiment II done at another time with another lot of animals confirms this result and shows further that the feeding of fresh muscle does not affect the consequence of splenectomy.

The feeding experiments were undertaken with the idea that if the resistance could thus be lowered it would be convincing evidence that the spleen was playing a functional part in relation to the infection, and it might be concluded from these experiments that some function affecting the progress of the disease was removed with the spleen and restored with the feeding. There are, however, certain facts in regard to the feeding experiments which lead us to refrain, for the present at least, from regarding the results as decisive. These factors may be discussed briefly under two heads.

1. The gross anatomical features of the disease in the splenectomized mouse fed with spleen differ from those found in the intact mouse. In the intact mice which die in less than thirty days one seldom encounters striking gross lesions in the lungs. Occasionally there are definite gray nodules from one to three millimeters in diameter. Early there may be no visible changes or there may be minute scattered gray points. In the mice which live longer than thirty days, the large nodules are found more frequently, although irregularly. There has seemed to be somewhat more exudation of this type in the splenectomized mice than in the intact mice which have lived longest, but we have been inclined to attribute this to the greater length of life, and to assume that the factors influencing exudation were not grossly changed by splenectomy. The most regular occurrence of large nodules in the lung has, however, been in those splenectomized animals which have been fed with spleen. The significance of this is not clear, and the observation is recorded merely as suggesting that feeding with spleen, while it lowers resistance, does not restore an entirely normal reaction.

2. When normal intact mice are fed daily with fresh spleen, they

eat with apparent relish and maintain their condition perfectly. The intact mice which were fed with spleen after inoculation with tubercle bacilli also ate with relish as long as they could be expected to retain desire for food.

The splenectomized mice when fed with spleen after inoculation took the first one or two feedings freely. After this time it was noted that they seemed not to care for it, and when they did eat of it they were apt to be sick. The illness took no very distinctive character. The animal would go to the corner of the jar and sit huddled up, with rough fur. This usually passed off in a few hours. On the following day, sometimes on the following two days, they would refuse to eat the spleen, although hungry for other food. After two or three days they would again eat spleen, show evidence of illness, and refuse it again on succeeding days. Several mice died in the course of a few hours after eating spleen. Some small hemorrhages in the serous membranes were noted in these animals, but as they were advanced with their infection the cause of death was not clear.

We have fed spleen to uninoculated, splenectomized mice. Of six mice so fed, two died within a few hours after eating spleen. These also showed a hemorrhagic condition of the serous membranes of the peritoneal cavity. The remaining mice showed the signs of illness with a distaste for the food which has been described, but lived and remained in good condition for upwards of two months, when the feeding was stopped. This indicates that there is an irregular, but more or less severe reaction to the feeding of fresh spleen in the case of splenectomized mice.

In view of the fact that uninfected splenectomized mice show some evidence of poisoning when fed with fresh spleen, a final opinion as to the reason for the loss of resistance as developed in the experiments reported in the above tables can hardly be drawn at present. It may be that a true function of the spleen controlling the reaction to the tubercle bacillus is removed by splenectomy and restored by feeding spleen. But it is not impossible that the shortening of life as manifested in the case of the splenectomized, infected, spleen-fed animals is due to some additional poison not directly related to the factors influencing the increased resistance after splenectomy. It is apparently the rule that the resistance of normal animals to infection with the tubercle bacillus is lowered by the continued administration of any poison that we are so far familiar with.

In the hope of getting further light on the reaction of the splenectomized animal to ingested spleen, we performed an experiment with dogs.

Two dogs were splenectomized and allowed to recover from the operation. They were kept for about two weeks on a mixed diet. Then with a normal dog for comparison the feeding was begun. The normal dog was fed entirely for over one month with fresh sheep spleen. He maintained his appetite and condition perfectly. One of the splenectomized dogs gave no reaction to spleen at any time. He was fed in alternate periods of several days with fresh chopped beef and with fresh ground sheep spleen.

The second splenectomized dog was fed from May 27 to June 4 with sheep spleen. On the 3d, 4th, 5th, and 6th days of this period, about twenty minutes after feeding, the animal had what appeared to be a slight chill. He lay down, the hair was roughened, and he had a general shivering tremor. The temperature remained normal. The tremor passed off in a few minutes but the animal remained quiet and indifferent to call for an hour or two. On the seventh day the animal became quiet but did not have the tremor. On the eighth day he had a slight tremor.

From June 5 to June 12 the dog was fed on fresh ground beef. He ate well and remained in good condition.

From June 13 to June 23 he was again fed sheep spleen. The first two days of the period he ate with apparent relish and showed no reaction. On the third day of the period he showed the same symptoms as those described during the first period. On the fourth day he ate, but showed no symptoms. On the fifth day he refused the food at first, but finally ate it and reacted as previously. On the sixth day he again ate with apparent distaste, but completed the meal very soon. He became very quiet and much depressed. For a time he seemed likely to vomit. On the following days of the period he refused to eat at first, but during the twenty-four hours consumed about half the quantity given. At the end of the period he had grown thin and was definitely out of condition.

From June 24 to 29 he was again fed fresh beef with the addition of boiled spleen, ate freely, and condition was rapidly regained. From June 27 to July 9 he was again fed sheep spleen alone, but showed no reaction at any time. He ate freely and maintained good condition.

While the result of this experiment is not entirely convincing, it increases the evidence drawn from the experiments with mice to the effect that fresh spleen is somewhat toxic for splenectomized animals.

SUMMARY.

The resistance to an infection with the tubercle bacillus which can be given to mice by the removal of the spleen is lost when fresh spleen, either of mouse or sheep, is added to the diet. The logical conclusion that splenic function in its relation to the specific infection is restored by feeding spleen cannot, however, be drawn; because, in the first place, the character of the disease in the splenectomized spleen-fed animals differs somewhat from that in intact animals; and, secondly, because fresh spleen when fed to splenectomized animals apparently gives rise to an acute intoxication.

This intoxication occurs quite regularly in mice. It is manifested in the infected animals and in those not inoculated. It has been seen in one of two splenectomized dogs experimented upon. Up to the present it can hardly be definitely characterized, but it seems to be best marked out by the specific anorexia associated with it.

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Vol. XXXVI. No. 5. May, 1914.]

[From the Henry Phipps Institute of the University of Pennsylvania.]

THE PREPARATION OF COMPOUNDS OF TRYPAN-RED WITH IODINE AND OTHER SUBSTANCES.

By Robert B. Krauss.

Received January 24, 1914.

It was found by Lewis[1] in 1912 in this laboratory that certain dyes, namely, trypan-red, trypan-blue, and isamine-blue, had a more or less selective affinity for different portions of the tuberculous tissue experimentally produced in the rabbit. Trypan-red, for example, when injected into a living animal which was suffering from tuberculosis, would be found after several days in considerable concentration in the central, more or less necrotic portions of the diseased tissues.

It was thought possible that this fact might be used as the basis for an attempt to distribute various physiologically active substances to the diseased tissue. Iodine was the active substance first selected. It was chosen because it is one of the few substances having any sustained reputation among physicians as a useful agent in the treatment of certain forms of localized tuberculosis. It is my purpose to present here, as briefly as possible, the purely chemical aspects of the work so far done. The physiological results obtained with the use of the substances whose preparation and analyses are presented in this paper will shortly be reported in an appropriate place.

The chemical problem, accordingly, was to prepare compounds allied physiologically to trypan-red and containing iodine in the molecule. We have been able to obtain three direct substitution products of trypan-red with iodine. A compound of iodoform and trypan-red has been produced. We were able to obtain compounds of the dyestuff with thymol, eucalyptol, guaiacol, phenol, the cresols, cinnamic esters and pyrrol. The compounds with these substances have been further varied by substitution with iodine.

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[1] Paul A. Lewis, "The Selective Relation of Certain Vital Stains to the Tubercle," *Arch. Intern. Med.*, 10, 68 (1912).

Experimental.

Method of Analysis.—The elementary analyses mentioned in this paper were conducted according to Dennstedt's simplified method, with the modification that a platinum capillary insert was used in place of the glass capillary of the original method, in order to avoid loss of time from breakage of the latter. Also, glass tubing with rubber connections was substituted for the rubber tubing of the method where it was feasible to do so, the former combination being sufficiently flexible to serve the purpose, obviating thereby the constant absorption of moisture through the rubber into the system.

Determinations of iodine were carried out also by the method of E. C. Kendall,[1] with slight modifications. These were for the most part very kindly furnished by Kendall himself, in the form of additional notes to his paper. We have made one slight departure of our own. This consisted of heating the crucibles in a firebrick[2] furnace having an insert (Fig. 1). By this means they were heated more indirectly and evenly than possible in his method. At the same time contamination from gases was totally eliminated.

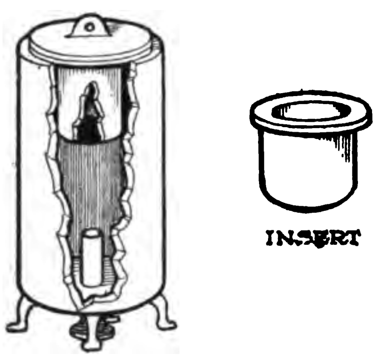
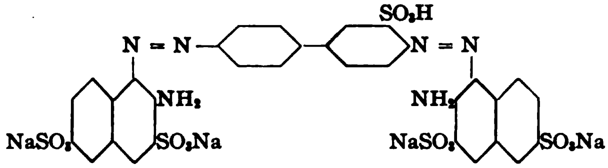


FIG. I

Trypan-red is a red dye very soluble in water, insoluble in alcohol. The manufacturers have not, to our knowledge, patented the preparation and have furnished no data as to its composition or the methods used in its manufacture. Ehrlich and Shiga first called attention to this dyestuff which they used in experiments, now classical, in the treatment of experimental infections with trypanosomes.

According to Ehrlich and Shiga[3] the composition of trypan-red is: Tetrazobenzidine monosulfonic acid (1 mol) coupled to β-naphthylamine disulfonate of sodium, R salt (2 mols). Structural formula:



These authors furnish no analyses of the substance and we are familiar with no published evidence for the formula given. Of the dyestuffs furnished commercially, even the purest does not correspond to this formula. In the various specimens analyzed wide variation in the sulfonic acid radical content was observed, as well as foreign organic substances, such as benzidine sulfone-sulfonic acid, benzidine di- and trisulfonic acids coupled variously with aminonaphthol sulfonic acids, Neville and Whinther's acid, amino G acid, amino R acid and amido H acid.

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[1] E. C. Kendall, This Journal, 34, 894 (1912).

[2] Crucible furnaces of this design made of fire clay in three pieces have been recently made to our order at a reasonable cost.

[3] Ehrlich and Shiga, *Berl. klin. Wochenschrift*, 41, 13 (1904).

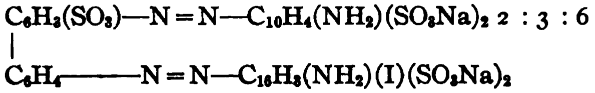
In the purification of the trypan-red considerable difficulty was accordingly encountered. It was deemed advisable to avoid separations with saline solutions owing to the difficulty of completely removing inorganic salts from the purified dyestuff. The purification was accomplished by a rather tedious fractional precipitation, using alcoholic solutions of widely variable concentration in conjunction with acetic and hydrochloric acids. The analysis of the purified material gave values approximately called for by the formula ($C_{32}H_{20}N_6S_5Na_4O_{15}$) of Ehrlich. The following is an example:

Calc.: C, 39.18; H, 2.04; N, 8.57; S, 16.33; Na, 9.39
Found: C, 39.20, 39.24; H, 2.14, 2.10; N, 8.59, 8.63; S, 16.40, 16.52; Na, 9.30, 9.34

In the interpretation of such results as we have obtained, we have assumed the substantial correctness of the formula. We have made certain attempts to prepare trypan-red from our own materials. When we have worked with purified components we have never succeeded in making the dye. On the other hand, as the result of the combination of impure benzidine monosulfonic acid as a rough sulfonation product and an impure R salt we have obtained a mixture of substances, from which we have been able to separate a large proportion of a dye having the chemical and biological characteristics of trypan-red.

We mention this matter because of its bearing on our failure to get some results which might have been expected from the formula. Briefly, benzidine monosulfonic acid can be combined with iodine in at least five different proportions. We have never, however, been able to combine the iodized benzidine with pure R salt in such a way as to give any substance having a resemblance biologically to trypan-red. In view of our failure to prepare trypan-red from pure components we do not consider it certain that iodized trypan-red with iodine substituted benzidine cannot be prepared. As above stated, we have been able to make a number of preparations containing iodine in the molecule and more or less closely resembling trypan-red in their biological properties. The methods which we have used, the analyses of the preparations and their probable formulas are briefly presented in the following paragraphs:

Compound $C_{32}H_{19}O_{15}N_6S_5Na_4I$, *Monoiodo Trypan-red*



$$\begin{array}{l} C_6H_3(SO_3)\text{—}N=N\text{—}C_{10}H_4(NH_2)(SO_3Na)_2 \; 2:3:6 \\ | \\ C_6H_4\text{———}N=N\text{—}C_{16}H_3(NH_2)(I)(SO_3Na)_2 \end{array}$$

Tetrazobenzidine monosulfonic acid coupled to monoiodo-β-naphthylamine disulfonic salt R and β-naphthylamine disulfonic R salt. This was prepared by treating 25 g. trypan-red in a flask with 16 g. of potassium iodide and 125 cc. water, then adding 25 cc. conc. sulfuric acid. The flask is attached to a reflux condenser and heated to boiling for an hour. After neutralizing with sodium carbonate solution the dyestuff is filtered, washed with dilute alcohol, absolute alcohol and dried at 110°. It is a crimson powder, soluble in water to a red solution. It is insoluble in alcohol, ether and benzol. Analysis:

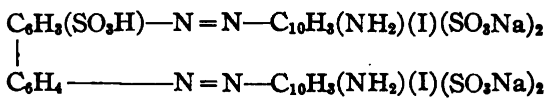
Calc. for $C_{32}H_{19}N_6S_5Na_4IO_{15}$: C, 34.72; H, 1.42; N, 7.59; S, 14.47; Na, 8.31; I, 11.48

Found: C, 34.76, 34.78; H, 1.70, 1.74; N, 7.58, 7.60; S, 14.48, 14.50; Na, 8.32, 8.34; I, 11.47, 11.47

When treated with KOH solution the dye turns to a violet color; with concentrated H_2SO_4, blue; on heating, iodine is given off.

Determination of the Location of the Iodine.—The dyestuff was dissolved in a little water and the solution made strongly alkaline with ammonia; zinc dust was then added and the solution heated to boiling, whereupon the the color disappeared. On acidifying, cooling, and filtering, the benzidine monosulfonic acid remains with the zinc dust on the filter, while the second components are in the filtrate as *o*-diamino sulfonic salts. The benzidine monosulfonic acid, when dissolved from the zinc, evaporated to dryness, and treated with concentrated sulfuric acid and warmed, does not give off any iodine. The filtrate from the zinc containing the naphthylamine fraction of the dye shows distinctly this reaction, therefore: All the iodine present is located in the β-naphthylamine disulfonic salt, and since one atom of iodine is present, only one molecule of the second component has been substituted.

Compound $C_{32}H_{18}N_6S_5O_{15}Na_4I_2$, *Di-iodo Trypan-red*



$$\begin{array}{l} C_6H_3(SO_3H)\text{—}N=N\text{—}C_{10}H_3(NH_2)(I)(SO_3Na)_2 \\ | \\ C_6H_4\text{————}N=N\text{—}C_{10}H_3(NH_2)(I)(SO_3Na)_2 \end{array}$$

Tetrazobenzidine monosulfonic acid coupled to monoiodonaphthylamine disulfonic acid R and monoiodonaphthylamine disulfonic acid R. This was obtained by treating 25 g. of trypan-red in a flask with 100 cc. of 50% alcohol and 50 cc. of saturated alcoholic solution of iodine in the presence of mercuric oxide. The flask is boiled under reflux for three hours. After cooling, the dye is filtered off and washed on the filter with alcohol, dissolved from the filter in hot water, the solution made acid with hydrochloric acid, saturated with hydrogen sulfide to remove any mercury present, filtered, boiled to expel hydrogen sulfide, filtered and evaporated to dryness. A red dyestuff is obtained which dissolves in water to a deep red solution. Reduction and examination, as before, showed the iodine to be present only in the β-naphthylamine salt.

Calc. for $C_{32}H_{18}N_6S_5Na_4I_2O_{15}$: C, 31.20; H, 1.46; N, 6.82; S, 12.98; Na, 7.47; I, 20.61.
Found: C, 31.11, 31.00; H, 1.46, 1.48; N, 6.81, 6.76; S, 12.96, 12.88; Na, 7.48, 7.50; I, 20.59, 20.60.

On treating the dye with concentrated potassium hydrate solution the color becomes violet; with concentrated sulfuric acid, blue, and on heating iodine is given off.

Iodoform Trypan-red.—On heating trypan-red with a large excess of iodoform in alcoholic solution under reflux for six hours, a dark brown compound of iodoform and trypan-red results. The dye is washed with alcohol until no more iodoform can be detected in the washings and then dried at 130°. This insures the removal of any remaining free iodoform.

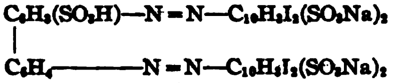
On standing, iodoform is slowly liberated only after considerable time. Heating with conc. H_2SO_4 turns the dye blue and iodoform is given off; with caustic potash the color change is to red-violet. The dried red-brown dye is completely soluble in water to bright red solution.

Calc. for $C_{32}H_{20}N_6S_5Na_4O_{15}.CHI_3$: I, 28.60. Found: I, 28.59, 28.60, 28.61, 28.54

Compound, $C_{32}H_{18}N_4O_{15}S_5Na_4I_4$, *Tetraiodo Trypan-red.*—By means of the Sandmeyer reaction, trypan-red yields an iodine derivative of dark brown color, which dissolves in water to a deep red solution with a violet tinge. Analysis showed the iodine to be present in the naphthalene disulfonic salt, and corresponding to four atoms iodine.

Calc. for $C_{32}H_{18}N_4S_5Na_4I_4O_{15}$: C, 26.37; H, 1.09; S, 10.98; N, 3.84; Na, 6.31; I, 34.89.
Found: C, 26.37, 26.20; H, 1.07, 1.04; S, 10.85, 10.78; N, 3.79, 3.80; Na, 6.18, 6.22; I, 34.87, 34.79, 34.88.

Formula:

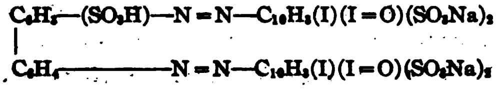


$$\begin{array}{l} C_6H_3(SO_3H)—N=N—C_{10}H_3I_2(SO_3Na)_2 \\ | \\ C_6H_4————N=N—C_{10}H_3I_2(SO_3Na)_2 \end{array}$$

Concentrated H_2SO_4 turns the dye dark blue and liberates iodine on warming; caustic potash gives a dark red color.

Compound, $C_{32}H_{16}N_4O_{17}S_5Na_4I_4$, *Diiodo-diiodoso Trypan-red.*—The preceding preparation dissolved in 20% sodium hydroxide was treated with a current of chlorine gas. The temperature of the solution was kept constant at 40°. A diiodo-diiodoso trypan-red was formed, having an active oxygen content of 2.09%. It oxidizes hydriodic acid, liberating iodine. This may be separated by shaking with chloroform and then can be titrated with thiosulfate.

Calc. for $C_{32}H_{16}N_4S_5Na_4I_4O_{17}$: C, 25.80; H, 1.08; N, 3.76; S, 10.75; Na, 6.04; I, 34.14. Active O, 2.09.
Found: C, 25.81, 25.63; H, 1.07, 1.05; N, 3.70, 3.78; S, 10.70, 10.65; Na, 6.06, 6.10; I, 34.08, 33.91; Active O, 2.09, 2.07.

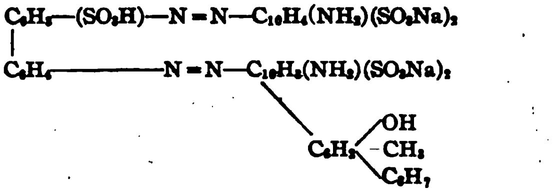


$$\begin{array}{l} C_6H_3—(SO_3H)—N=N—C_{10}H_3(I)(I=O)(SO_3Na)_2 \\ | \\ C_6H_4————N=N—C_{10}H_3(I)(I=O)(SO_3Na)_2 \end{array}$$

Compound, $C_{42}H_{32}N_6O_{16}S_5Na_4$, *Thymol Trypan-red.*—This dyestuff is formed when 25 g. trypan-red, 300 cc. 50% alcohol and 15 g. thymol are boiled together in a flask under reflux for 24 hours. It is a crimson dye of the above composition, soluble in water to a crimson solution and insoluble in alcohol. The dye turns dark blue with concentrated sulfuric acid, liberating thymol on heating. With caustic potash the color is yellow-red.

Calc. for $C_{42}H_{32}N_6Na_4S_5O_{16}$: C, 44.68; H, 2.83; N, 7.44; Na, 8.15; S, 14.18.

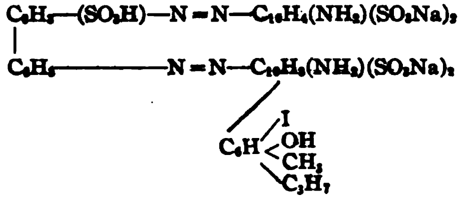
Found: C, 44.72, 44.82; H, 2.88, 2.90; N, 7.48, 7.54; Na, 8.16, 8.25; S, 14.20, 14.28.



Compound, $C_{42}H_{31}O_{16}N_6S_5Na_4I$, *Iodothymol Trypan-red.*—Thymol trypan-red (25 g.) was treated with 30 g. sodium hydroxide, 200 cc. water, and 10 g. iodine and then warmed to 80°. As soon as the reaction is completed the solution is neutralized with hydrochloric acid, the dyestuff separating out. It is washed on the filter with alcohol and dried. The scarlet powder is soluble in water to a scarlet solution. On warming the dye with concentrated H_2SO_4 iodine is liberated.

Calc. for $C_{42}H_{31}N_6Na_4S_5I.O_{16}$: C, 40.18; H, 2.47; N, 6.69; S, 12.75; Na, 7.34; I, 10.12.

Found: C, 40.18, 40.12; H, 2.50, 2.62; N, 6.65, 6.68; S, 12.80, 12.72; Na, 7.32, 7.19; I, 10.08, 10.16.

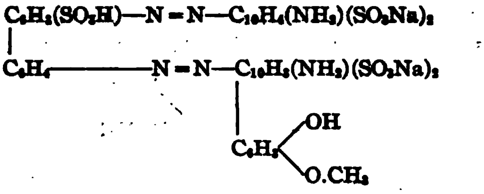


Compound, Eucalyptol Trypan-red.—This was formed when 15 g. trypan-red, 5 g. eucalyptol, and 50 cc. of 80% alcohol are heated under reflux to boiling for three hours. The insoluble eucalyptol trypan-red is filtered off and washed with alcohol. It is a red-brown dye of varied composition, soluble in water to a red solution. An iodine derivative of this dyestuff was also prepared.

Compound, $C_{39}H_{28}N_6O_{17}S_5Na_4$, *Guaiacol Trypan-red.*—Finely divided trypan-red (25 g.) is heated with 10 g. guaiacol and 300 cc. 50% alcohol, for three hours under reflux. On cooling, the dyestuff settles out, is filtered, and washed with alcohol and dried at 110°. It is a red-brown powder soluble in water to a red solution with a yellow tinge.

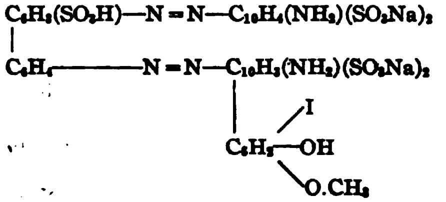
Calc. for $C_{39}H_{28}N_6S_5Na_4O_{17}$: C, 42.39; H, 2.62; N, 7.60; S, 14.48; Na, 8.34.

Found: C, 42.39, 42.27; H. 2.61, 2.66; N, 7.61, 7.64; S, 14.49, 14.20; Na, 8.33, 8.41.



Compound, $C_{39}H_{25}N_6O_{17}S_5Na_4I$, *Iodoguaiacol Trypan-red.*—Prepared by heating 15 g. trypan-red, 6 g. iodoguaiacol and 150 cc. 50% alcohol as under the preceding. The dark brown dye which results is soluble in water to a red solution with a slight yellow tinge. Sulfuric acid liberates iodine from the dye on heating. Caustic potash gives a yellow-red color.

Calc. for $C_{39}H_{25}N_6S_5Na_4IO_{17}$: C, 38.08; H, 2.11; N, 6.84; S, 13.02; Na, 7.49; I, 10.34. Found: C, 38.17, 38.07; H, 2.12, 2.14; N, 6.82, 6.76; S, 13.01, 13.06; Na, 7.47, 7.50; I, 10.33, 10.28.



Compound, $C_{36}H_{22}N_7O_{15}S_5Na_4$, *Pyrrol Trypan-red.*—When 15 g. trypan-red, 5 g. pyrrol and 100 cc. of 50% alcohol are heated under reflux for three hours, a condensation of pyrrol and trypan-red takes place and a red-brown dye of the above composition is formed. It is soluble in water to a yellow-red solution and insoluble in alcohol and ether. The dye does not give a reaction for pyrrol with isatin and sulfuric acid or phenanthraquinone.

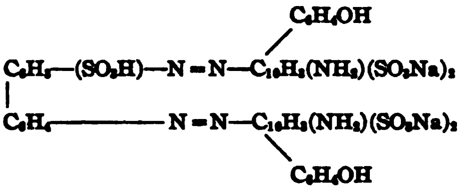
Calc. for $C_{36}H_{22}N_7Na_4S_5O_{15}$: C, 41.27; H, 2.39; N, 9.35; Na, 8.79; S, 15.28.
Found: C, 41.26, 41.20; H, 2.39, 2.35; N, 9.34, 9.38; Na, 8.78, 8.82; S, 15.30, 15.27.

Compound, $C_{36}H_{19}N_7O_{15}S_5Na_4I_4$, *Tetraiodopyrrol Trypan-red.*—This dye is formed when tetraiodopyrrol (from pyrrol and iodine in alkaline solution) is treated with trypan-red as in the preparation of pyrrol trypan-red. The tetraiodo dye is a dark brown salt soluble in water to a red solution. On addition of concentrated H_2SO_4 the dye turns blue and iodine is liberated on warming.

Calc. for $C_{36}H_{19}N_7I_4Na_4S_5O_{15}$: C, 27.88; H, 1.23; N, 6.32; I, 32.79; Na, 5.94; S, 10.32.
Found: C, 27.85, 27.80; H, 1.28, 1.35; N, 6.31, 6.28; I, 32.75, 32.70; Na, 5.96, 5.93; S, 10.31, 10.42.

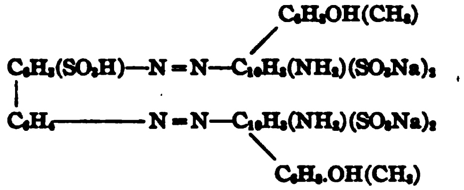
Compound, $C_{44}H_{28}N_6O_{17}S_5Na_4$, *Phenol Trypan-red.*—Obtained by heating trypan-red under reflux with an excess of phenol in alcoholic solution for three hours. It is a crimson dye, soluble in water to a yellow-red solution. This dye does not give tests for phenol. On heating with concentrated sulfuric acid the phenol is split off.

Calc. for $C_{44}H_{28}N_6Na_4S_5O_{17}$: C, 44.82; H, 2.37; N, 8.31; Na, 7.81; S, 13.58.
Found: C, 44.95, 44.90; H, 2.39, 2.57; N, 8.28, 8.26; Na, 7.68, 7.70; S, 13.51, 13.62.


C₆H₄OH
C₆H₃—(SO₃H)—N = N—C₁₀H₃(NH₂)(SO₃Na)₂
C₆H₄———N = N—C₁₀H₃(NH₂)(SO₃Na)₂
C₆H₄OH

Compound, $C_{46}H_{32}N_6O_{17}S_5Na_4$, *Di-o-cresol Trypan-red.*—On heating trypan-red with an excess of alcoholic *o*-cresol under reflux for three hours, a red-brown dye is formed which is soluble in water to a red solution. The dye is not broken down by heating the solution, nor can a test for cresol be obtained. Boiling with conc. sulfuric acid turns the dye blue and splits off cresol.

Calc. for $C_{46}H_{32}N_6Na_4S_5O_{17}$: C, 46.30; H, 2.68; N, 7.04; Na, 7.71; S, 13.42.
Found: C, 46.26, 46.42; H, 2.74, 2.78; N, 7.08, 7.11; Na, 7.89, 7.73; S, 13.38, 13.30.

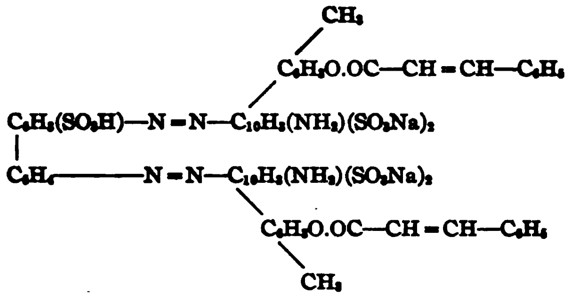

C₆H₃OH(CH₃)
C₆H₃(SO₃H)—N = N—C₁₀H₃(NH₂)(SO₃Na)₂
C₆H₄———N = N—C₁₀H₃(NH₂)(SO₃Na)₂
C₆H₃.OH(CH₃)

In the same manner di-*m*-cresol trypan-red, a dark red-brown dye, and di-*p*-cresol trypan-red, a dark red-brown dye, were prepared. With sulfuric acid the *m*-derivative gives a violet-blue color and the *p*-derivative a dark blue color. By treating these three isomers with iodine in caustic soda solution, and then neutralizing with acid, their iodine substitution products are obtained. In this way were made di-*o*-triiodocresol trypan-red, $C_{46}H_{26}N_6O_{17}S_5Na_4I_6$; di-*m*-triiodocresol trypan-red, $C_{46}H_{26}N_6O_{17}S_5Na_4I_6$; di-*p*-triiodo cresol trypan-red, $C_{46}H_{26}N_6O_{17}S_5Na_4I_6$.

Calc. for 6I, 39.69%.
Found for *o*-deriv. 39.64, 39.64; *m*-deriv., 39.62, 39.65; *p*-deriv. 39.67, 39.70.

Compound, $C_{64}H_{44}N_6O_{19}Na_4S_5$, *Dicinnamyl-di-o-cresol Trypan-red.*—Prepared by treating, in a flask, 146 pts. di-*o*-cresol trypan-red, 18 pts. sodium cinnamate, and 100 pts. benzene in the cold with 9 pts. phosporous pentachloride and then heated under reflux until the evolution of hydrochloric acid has ceased. The benzene is then poured off and the residue neutralized with sodium carbonate. It is a red dye soluble in water to a red solution. Sulfuric acid turns it blue and caustic soda to a yellow-red solution.

Calc. for $C_{64}H_{44}N_6Na_4S_5O_{19}$: C, 52.89; H, 3.03; N, 5.76; Na, 6.33, S, 11.01.
Found: C, 55.71, 52.76; H, 3.06, 3.14; N, 5.78, 5.81; Na, 6.31, 6.39; S, 10.97, 11.08.

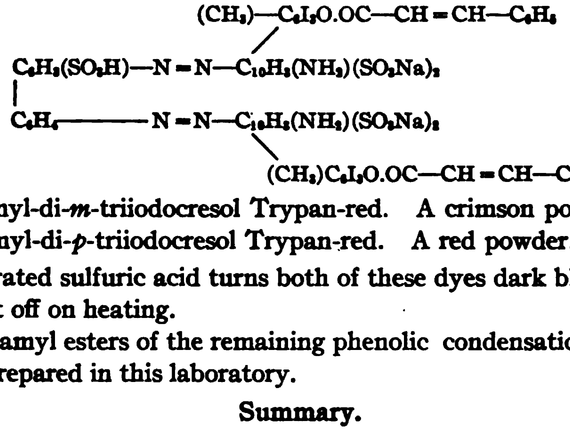


Dicinnamyl-di-*m*-cresol Trypan-red. Color scarlet.

Dicinnamyl-di-*p*-cresol Trypan-red. Color dark red.

Compound, $C_{64}H_{38}O_{19}N_6S_5Na_4I_6$, *Dicinnamyl-di-o-triiodocresol Trypan-red.*—Prepared according to the method indicated in the preceding paragraph, using di-*o*-triiodo trypan-red as a starting point. The dyestuff obtained is a crimson powder easily soluble in water to a red solution, giving with concentrated sulfuric acid a blue color, and on heating this iodine is split off.

Calculated for $C_{64}H_{38}N_6Na_4S_5I_6O_{19}$: C, 34.78; H, 1.72; N, 3.80; Na, 4.16; S, 7.24· I, 34.51. Found: C, 34.76, 34.70; H, 1.68, 1.94; N, 3.79, 3.65; Na, 4.11, 4.23; S, 7.23, 7.21; I. 34.47, 34.43.



Dicinnamyl-di-*m*-triiodocresol Trypan-red. A crimson powder.

Dicinnamyl-di-*p*-triiodocresol Trypan-red. A red powder.

Concentrated sulfuric acid turns both of these dyes dark blue and iodine is then split off on heating.

The cinnamyl esters of the remaining phenolic condensations mentioned are being prepared in this laboratory.

Summary.

1. Iodine derivatives of trypan-red of similar color, solubility and biological qualities were prepared.
2. An iodoform addition product of trypan-red of definite composition was prepared.
3. Condensation products of trypan-red and phenol, the cresols, thymol, guaiacol, pyrrol and their iodine substitution products of definite compositions were prepared.
4. Condensation products of trypan-red with eucalyptol and its iodine derivative of indefinite composition were prepared.

5. Cinnamic esters of the cresol trypan-reds and of the iodocresol trypan reds of definite composition were prepared.

In conclusion the author wishes to express his gratitude to Paul A. Lewis, who suggested the present investigation.

PHILADELPHIA, PA.

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THE IODINE CONTENT OF TUBERCULOUS TISSUES.

BY PAUL A. LEWIS AND ROBERT B. KRAUSS.

(From the Henry Phipps Institute of the University of Pennsylvania.)

(Received for publication, June 2, 1914.)

During the past two years we have prepared a number of compounds of iodine with the dyes Trypan-red[1] and Trypan-blue and have studied them in animal experiments with the idea that the well-known action of these dyes as vital stains might be used to distribute physiologically active iodine to tuberculous tissue. A number of the dye-stuff compounds with iodine are vital stains with much the same factors of distribution as the original dyes. As in the case of the mother substances many of these iodized dyes show considerable tendency to concentrate in the experimental tuberculous tissues of the rabbit.[2]

In working with such compounds, however, it is somewhat difficult to overcome certain theoretical objections which might be raised; for example, many of these compounds are without obvious physiological action in the tissues to which they are distributed. The amounts in question are so small that tests for the excretion of iodine to determine whether or not the compound was broken down and merely the original dye-stuff deposited in the tissue cannot be satisfactorily made. From the chemical point of view, it is difficult to separate completely the iodine compound from the mother dye. There thus remained the possibility that some of the unchanged original dye might be responsible for the vital stain of the tuberculous tissue. It seemed advisable, therefore, to select a typical example for analysis in which the tuberculous tissue in the treated animal could be studied for its iodine content.

We are aware of two previous attempts to study the relation of iodine to tuberculous tissue. The first of these was by Loeb and

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[1] Krauss: *Journ. Amer. Chem. Soc.*, xxxvi, p. 961, 1914.

[2] Lewis: *Arch. of Int. Med.*, x, p. 68, 1912.

Michaud.[3] These observers used rabbits. One eye was inoculated with tubercle bacilli and after a suitable interval potassium iodide was administered to the animal. Sometime later the animals were killed and the tuberculous eyes were examined for their iodine content in comparison with the normal eyes. It was found that the tuberculous eyes uniformly showed an appreciably higher iodine content than the normal. In these experiments there would at first sight seem to be a satisfactory control. In other experiments the lymph glands of tuberculous guinea pigs which had been treated with iodoform and ethyl iodide were used. In these cases the presence of iodine at the time of examination was considered by the authors as sufficient evidence that it was derived from the substances administered. Wells and Hedenburg[4] repeated these experiments on a larger scale. Their methods of analysis were improved. The results were essentially the same as far as the examination of the tissues was concerned.

Our first experiment gave an unexpected result which called attention to a defect in the previous observations. We found in this experiment (see table, p. 315) that in some instances the tuberculous tissue from untreated animals contained appreciable quantities of iodine. This has led us to make some further examination of tuberculous tissue for its iodine content.

Method. The tissues for examination were prepared as follows: Healthy rabbits were chosen and the inoculations were made on one cornea with a virulent culture of tubercle bacilli of bovine type. After an interval of about three weeks, when the lesion was well developed, the animals were killed, the eyes removed, washed free of blood, and the cornea separated from the remainder of the eye. The tuberculous cornea was examined for iodine, the normal cornea being examined as control. As a check on the method of analysis in some instances, all of the remainder of the eyes was analyzed. In the instances where the tuberculous lung tissue was examined in comparison with the normal lung tissue, the animals after a corneal inoculation were allowed to live much longer, until the disease had become generalized. In the early stages of generalization after this method of inoculation, discrete foci of tuberculosis varying from 1 to 5 mm. in diameter are found in the lungs while the intervening tissue is practically normal. The separation of the tuberculous tissue from the normal lung tissue is relatively easy. In some instances the thyroids of the same rabbits were analyzed for iodine by the same method. The rabbits during the period of the experiment, were confined in separate cages and were fed on the regular diet consisting of a mixture of stale bread and oats soaked for some time in water, with the addition of fresh cabbage two or three times a week.

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[3] Loeb and Michaud: *Biochem. Zeitschr.*, iii, p. 307, 1907.

[4] Wells and Hedenburg: *Journ. of Inf. Diseases*, xi, p. 349, 1912.

The method of analysis for iodine was essentially that of Kendall[5] with certain modifications which were for the most part kindly suggested by Kendall himself. The disintegration of the tissue was carried out in a crucible furnace of our own design which we have recently described[6] in connection with the analysis of our Trypan-red iodine compounds. Our results are contained in the following table. The results are expressed as milligrams of iodine per gram of dry tissue.

RABBIT NO.	TUBERCULOUS		NORMAL			
	Tissue	Iodine content	Tissue	Iodine content	Tissue	Iodine content
			Untreated.			
666*	Cornea	0.276	Cornea	0.157	Rest of eyes	0
671*	Cornea	0	Cornea	0	Rest of eyes	0
683*	Cornea	0	Cornea	0	Rest of eyes	0
992‡	Cornea	0	Cornea	0		
997‡	Cornea	0.200	Cornea	0	Thyroid	1.383
997†	Cornea	2.67	Cornea	0		
934*	Lung	0	Lung	0	Thyroid	1.565
892*	Lung	0	Lung	0	Thyroid	1.500
			Treated with di-iodo-trypan red.			
665*	Cornea	1.181	Cornea	0.763	Rest of eyes	0
674*	Cornea	1.107	Cornea	0.679	Rest of eyes	0
673*	Cornea	1.068	Cornea	0.383	Rest of eyes	0
669*	Cornea	1.085	Cornea	0.317	Rest of eyes	0

* Experiment done, May 1913.
† Experiment done, February 1914.
‡ Experiment May 1914.

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[5] Kendall: *Journ. Amer. Chem. Soc.*, xxxiv, p. 894, 1912.

[6] Krauss: *loc. cit.*

DISCUSSION.

Throughout our experiments it has developed that the tuberculous cornea may contain a very appreciable amount of iodine. The normal cornea has been found to contain iodine but once in the untreated normal animal (Rabbit 666, of table.) In the case of the rabbits treated with our preparation No. 10 (di-iodo-trypan-red), the normal cornea contains much more iodine than the single normal cornea in which iodine was present, and the tuberculous tissue shows still higher values. We feel therefore that by means of our Trypan-red compound we have probably placed iodine in the tuberculous tissue. The fact, however that the tuberculous cornea in the one of the untreated rabbits which showed an iodine content in the cornea gave a much higher value for the tuberculous eye than for the normal eye and the fact that in other experiments iodine has been found in the tuberculous cornea when it was not present in the normal cornea led us to feel that a certain reserve is necessary in drawing conclusions from this form of experimentation. Our experiments of course throw no real light on the reason for the presence of iodine in the untreated tuberculous tissue. They indicate that it is present with some regularity and suggest an interesting field for further study. When one examines the results presented by Loeb and Michaud and by Wells and Hedenburg in the light of our analysis of untreated tuberculous tissue, it becomes apparent that their conclusions also must for the present be accepted with reserve. These authors present no analysis of tuberculous tissue in untreated animals and while some of the figures which they present are high enough to make it probable that the iodine found was derived from the iodine administered, there are a number of other quantities which can hardly be considered significant. Loeb and Michaud give as their highest figure for iodine in the tuberculous eye of rabbits treated with potassium iodide 0.58 mgm. per gram. Our highest figure for the tuberculous tissue is 2.67 mgm. per gram calculated on the dry weight. While it is not specifically stated, their calculation is probably on the basis of the moist weight. Calculated on this basis our high figure for the untreated eye would be 0.53 mgm. per gram or much the same as their high figure for the treated animal. As we know nothing of the influence of various articles of diet and conditions of the various organs, particularly of the thyroid, on the iodine content of specifically inflamed tissue, it seems impossible at this time to draw final or even valuable conclusions on the basis of any such method of experimentation.

SUMMARY.

Tuberculous tissue derived from animals to which no iodine preparation has been knowingly administered may contain amounts of iodine very appreciably higher than normal control tissue of the same animal. While it is quite probable that tuberculous tissue in animals treated with iodine products may store up iodine, this has been by no means clearly shown in any experiments so far reported. The highest figures for the tuberculous tissue of untreated animals in our experience may equal the highest figures of those reported by others as evidence for the localization in the tissue of iodine intentionally administered.

SOME STRUCTURAL TRANSFORMATIONS OF THE BLOOD-CELLS OF VERTEBRATES

G. L. KITE

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SOME STRUCTURAL TRANSFORMATIONS OF THE BLOOD-CELLS OF VERTEBRATES

G. L. KITE

(From the Henry Phipps Institute of the University of Pennsylvania, Philadelphia, Pa.)

PLATE 2

The current descriptions of the structure of vertebrate blood-cells are largely based on material which has been prepared by the smear method and coagulated by heat, alcohol, or mixtures of electrolytes. The activities of white cells, that are generally recognized, are slow ameboid movement by means of either blunt or fine pseudopods, and the engulfment of objects by means of active pseudopods.

The numerous recent investigations on blood-cells made with the aid of the dark-field method of illumination have added interesting points of detail to previous knowledge of the form and activities of the cellular elements of the blood. No convincing evidence has been brought forward to show that the widely held notions about vertebrate blood-cells are seriously at fault. This fact is clearly due to the confusion caused by the presence of fibrin granules and threads in preparations made by the usual methods. In fact, many of the recent investigations are nothing more than the description of attempts to interpret the complex and variable images of the structural elements of blood clots which are produced by oblique illumination on a dark background.

By the employment of a special mounting or culture medium, I have been enabled to determine that both white cells and erythrocytes of all classes of vertebrates may undergo many marked structural transformations, which are of a reversible nature. In this paper, the more important of these transformations, so far observed, will be described.

MATERIAL AND METHODS

The blood-cells of fishes, amphibians, reptiles, birds, and mammals have been studied. Particular attention has been given to the blood-cells of the frog, the rabbit, and man. The actual species, so far used, include common mammals, as the mouse, goat, guinea-pig, rabbit, monkey (Macacus rhesus), and man, and in addition the goldfish

(Carassius auratus), bullfrog tadpole (Rana catesbiana), leopard frog (Rana pipiens), painted turtle (Chrysemis picta), and pigeon (Columba livia).

A detailed description of the microdissection method employed will soon be published. It will suffice to state that the method has been developed to the point where it is adequate for the determination of the colloidal structure of living matter. Such structural elements of living cells as nuclei, nucleoli, pieces of chromatin networks, globules, granules, chromosomes, and spindle fibers may be cut out of living animal and plant cells and their exact physical properties and relationships determined. A new microdissection apparatus has been designed embodying the well-known ball-bearing principle. The three micrometer screws in this apparatus are made with the accuracy common to the best microtomes. Special achromatic and apochromatic condensers, giving long working distances, are essential for the dissection of cells under oil immersion objectives.

A 2 mm. Zeiss objective of 1.40 N. A., Comp. Ocs. 6 and 8, and W. Watson and Sons' holoscopic oil-immersion condenser, have been used for observing living blood-cells and for microdissections. The dark-field method of illumination has also been employed with notable success.

Liquid plasma, diluted with Ringer's fluid, which contains sufficient hirudin to permanently prevent coagulation, has been generally employed as the mounting medium. The technic which I have found best for the preparation of the blood-cells for observation and microdissection is very simple. About one milligram of hirudin is added to 2 or 3 c.c. of sterile Ringer's fluid in a small flask. About 0.5 c.c. of this mixture is drawn into a pipet which is applied to a drop of fresh blood obtained by the usual puncture method. The blood and Ringer's fluid are quickly blown into the flask containing the Ringer's fluid and hirudin. This operation is repeated until the Ringer's fluid has a definite red color. If sufficient hirudin has been added to the Ringer's fluid, and reasonable deftness be shown in getting the blood well mixed with the Ringer's fluid, neither fibrin granules nor threads are formed and the platelets are not clumped. Microscopical examination of a drop of this mixture should show the blood-cells evenly distributed through the liquid, and widely enough spaced to give optimum conditions for the exhibition of activities by the cells.

This use of hirudin is based on the work of Bodong,[1] and Abel, Rowntree, and Turner.[2] Bodong has demonstrated the harmlessness of even large quantities of hirudin for rabbits, and Abel, Rowntree, and Turner could show no detrimental action of this substance on dogs. Hirudin has given equally satisfactory results with the blood-cells of all vertebrates so far tried. The simple method of using hirudin that I have described is so satisfactory that it may find wide usage among those interested in the microscopic examination of fresh blood. Further, it seems that plasma, kept liquid by the employment of hirudin, used either undiluted or diluted with an appropriate salt solution may prove of great value in the in vitro cultivation of many other types of cells, besides the formed elements of the blood.

The results obtained by the hirudin method have been controlled by the use of defibrinated blood and by the addition of citrate and oxalate to prevent coagulation. While similar physical changes of the blood-cells may be observed when these more usual methods are employed, no evidence could be adduced to show that such methods of handling blood-cells for in-vitro studies have anything but disadvantages as compared with liquid-plasma and Ringer's fluid containing a trace of hirudin.

The observations and microdissections of the blood-cells of cold-blooded vertebrates were made at room temperature; those of birds and mammals at both room temperature and at body temperature. The structural transformations of blood-cells are so similar for all classes of vertebrates that the descriptions may be largely limited to those of the rabbit and man.

THE COLLOIDAL STRUCTURE OF THE CYTOPLASM OF HUMAN POLYMORPHONUCLEAR LEUKOCYTES

Microdissections of polymorphonuclear leukocytes, under oil-immersion objectives, have shown that the usual descriptions of their structure are entirely erroneous. The cytoplasm of the white cells of all classes of vertebrates has nothing of the nature of a cell membrane. The surfaces of these cells are as completely naked as those of Rhizopods, nor does the living leukocyte cytoplasm contain a spongioplasm and hyaloplasm. The cytoplasm of this cell is a jelly in which are imbedded large numbers of globules. A very thin surface layer of cytoplasm goes more or less completely into solution when the surface is incised or extensively torn with glass dissecting needles. This change is so rapid and affects such a small mass of the living cytoplasmic jelly that it may be easily overlooked even when the dissections are made under oil-immersion objectives. With this exception the cytoplasm of polymorphonuclear leukocytes does not change rapidly as a result of mechanical injury. If pieces of the living cytoplasmic jelly between the globules are torn out, they are found to be optically homogeneous or monophasic in molar structure. The well-known turbidity of the living polymorphonuclear leukocyte is due to the globular component; the cytoplasm proper is almost transparent and has extremely little scattering action on light. The structures usually termed cytoplasmic granules are of the nature of separation products; they do not grade into the surrounding cytoplasm. In my terminology, such components of the living substance are termed globules or spherules while those that grade into the imbedding substance are termed granules. This is believed to be a fundamental physical distinction. It is almost impossible to free the globules entirely from the remarkably glutinous cytoplasm. The substances that form the globules change their distribution in the different phases of the leukocyte. In one phase, the globules are localized in one small area of cytoplasm. In other phases, the globules vary greatly in size in different parts of the same cell. The structural death-changes are also commonly associated with marked redistribution of the globular material.[3] Spermatazoa and the spermatocytes of insects are the only cells, so far dissected, that may be compared in glutinosity to leukocytes. The cytoplasm is soft and may be easily pulled out into long strands which contract considerably when freed. Pieces of the cytoplasmic jelly do not round up when torn out in diluted plasma. Jams made from colorless berries show physical and optical properties that are in many ways similar to those of the cytoplasm of leukocytes.

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[1] *Arch. f. exper. Path. u. Pharmakol.*, 1904, 52, p. 242.
[2] *Jour. pharmakol. and Exp. Therapy*, 1913, 5, p. 275.

STRUCTURAL TRANSFORMATIONS OF POLYMORPHONUCLEAR LEUKOCYTES

The citation of an actual experiment may serve to illustrate the nature of the structural transformations observed. A drop of diluted human blood prepared according to the hirudin method was mounted and sealed with vaselin. The preparation was immediately transferred to a microscope incubator and examined by dark field illumination. Most of the leukocytes extend blunt pseudopods and by this means flow slowly across the field. Inside of fifteen minutes many leukocytes may be observed to undergo a marked surface change. A surface layer of from one to three or more microns in thickness becomes optically delineated from the underlying substance. This stage is shown in Figure 1, *a*. In less than thirty minutes many leukocytes are seen, covered with delicate protoplasmic processess which may assume

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[3] For similar observations see Schilling, *Folia haematol.*, 1908, 6, p. 429.

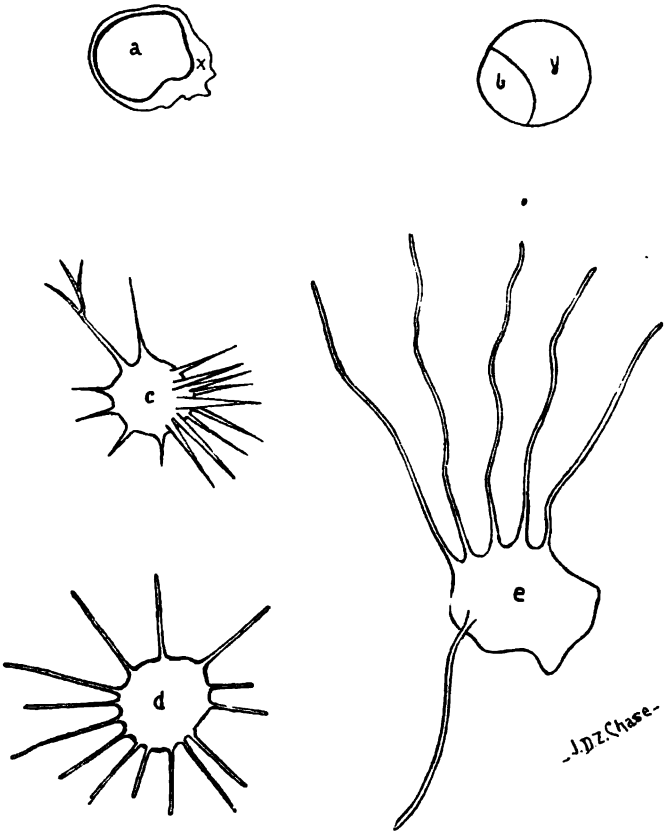

Fig. 1.—Camera drawings of living human polymorphonuclear leukocytes.

a=Hyaline-surface phase: x=Hyaline surface layer; b=Hyaline phase; y=Hyaline area; c=Fine pseudopodial phase; d=Ciliated phase; e=Flagellated phase. The processes usually have an irregular distribution over the surface of the leukocytes, but this important structural detail could not be brought out well in the camera drawings.

All camera drawings were made with 1.8 mm. Zeiss homogeneous immersion objective, No. 6 compensating ocular, and parabaloid condenser.

at least three different forms, namely, fine, long immobile pseudopods that frequently branch, short cilium-like processes, and long delicate processes which have the rapid undulatory movement characteristic of flagella. The protrusion and retraction of the different kinds of processes have been observed many times. Leukocytes with as many as twelve or fifteen long undulating processes in one focal plane have been observed to retract all processes in the course of a few seconds and become typical ameboid cells.

The more important distinct forms or phases of the leukocyte are shown diagrammatically in Figures 1 and 2. The hyaline surface phase is characterized by an extraordinary viscidity of the surface. If two leukocytes in this phase are brought in contact, fusion at the point of contact occurs. If the surface of such a leukocyte is touched with a glass dissecting needle and the needle drawn away, a minute thread of hyaline cytoplasm may be seen connecting the point of the needle with the leukocyte. When motile bacteria strike this layer they stick and generally do not seem to be able to free themselves. The violent jerking movements made by the bacteria may serve to imbed them firmly in the surface of the leukocytes. Observations of the mesenteries of frogs, exposed to air, indicate that the well-known accumulation of leukocytes on the walls of the small blood-vessels is due, primarily, to a marked increase in viscidity of the surface layers

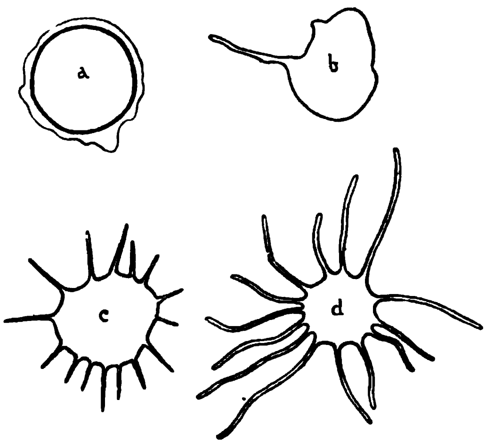

Fig. 2.—Camera drawings of living polymorphonuclear leukocytes of the rabbit. a = Hyaline-surface phase; b and c = Ciliated phase; d = Flagellated phase.

of the leukocyte cytoplasm. The important power of undergoing rapid variation in surface viscidity, in response to slight environmental changes, is not limited to the white blood-cells of vertebrates, since Hardy[4] has given an excellent description of this phenomenon in the blood-cells of Daphnia.

The pseudopodial phase of a human polymorphonuclear leukocyte is shown in Figure 1. Processes of this type are subject to the widest variation and in some cases reach extraordinary lengths. In 1891 Ranvier[5] described frog lymphocytes with numerous long pseudopods, under the name of "clasmatocytes." Ranvier considers clasmatocytes to be new types of cells. It appears that retraction of the pseudopods was not observed. More recently Joly[6] has figured the clasmatocytes of Ranvier.

In the ciliated phase the processes are usually numerous and vary in length from about four to ten microns. The processes exhibit an uncoordinated cilium-like beating. A part of the processes on a cell may be motionless, while others show rapid movement. When the processes reach a length of from ten to thirty or more microns they have the undulatory motion common to flagella. Such forms may be considered flagellated phases. Both the ciliated and flagellated phases may be free-swimming. On account of the lack of coordination in the movements of the processes, such leukocytes follow a very irregular path when moving across the field.

As far as I have been able to determine, both mononuclear and polymorphonuclear white blood-cells of all classes of vertebrates may undergo these strange changes. A peculiar redistribution change that has been frequently observed is characterized by the hyaline character of the greater part of the cell-substance. In this phase the globules are localized in a small area of the cytoplasm.

In this connection two recent papers that have a general bearing on structural transformations in cells may be mentioned. Holmes[7] has described the transformation of hexagonal peritoneal epithelial cells of the frog into ciliated cells which in turn become ameboid. Holmes writes, "One would not suspect these (ameboid) cells to be derived from ciliated epithelium were it not for the fact that one can actually observe their transformation." In an important study of an ameba of the limax group, Wherry[8] describes the transformation under certain conditions of typical amebae into flagellates. Wherry states that the pressure of a cover glass was generally sufficient to cause the change of the free-swimming flagellated forms back into amebae.

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[4] *Jour. Physiol.*, 1892, 13, p. 165.
[5] *Compt. rend. Acad. d. sc.*, 1891, 112, p. 688.
[6] *Arch de méd. expér. et d'anat. path.*, 1898, 10, p. 616.
[7] *Science, New Series*, 1914, 39, p. 107.

STRUCTURAL CHANGES IN MYELOCYTES

A number of observations have been made on the blood-cells from a case of myelogenous leukemia. Myelocytes with pseudopods and long flagellum-like processes are shown in Figures 1 and 3, Plate 2. In preparations of leukemic blood, prepared by the hirudin method, the myelocytes seemed to be the first cells to extrude processes. Large myelocytes, covered with numerous long undulating processes, make striking microscopic pictures.

In both normal and leukemic blood a small body, about three microns in diameter, containing a few granules and having from one to four long delicate processes, has been observed. The exact identity of this structure has not been determined.

THE BEHAVIOR OF UNATTACHED PROCESSES

Processes that have lost their connection with cells have an independent undulatory movement. A single free process has been observed to retain its characteristic activity unimpaired for over one hour. A process that lies obliquely in the focal plane of an objective actually simulates a spirochete. Such unattached processes seem undoubtedly to be a source of the pseudo-spirochetes of normal blood, so familiar to those investigators who work much with dark field illumination.

It appears certain that active unattached processes have been observed by Rosenthal,[9] Beer,[10] Chambers,[11] Ketron,[12] and others; yet, it should be recalled that preparations made according to the usual methods contain plain and beaded threads of fibrin, which may closely simulate the unattached processes of blood-cells. Besides, Ketron states, "If blood is allowed to flow in a citrate solution to prevent clotting none of these bodies are found and I was not able to produce them by trauma." And further, "These results seem to give definite proof that these pseudo-organisms are most likely products of fibrin formation."

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[8] *Arch. f. Protistenkunde*, 1913, 31, p. 77.
[9] J. Rosenthal, Festschrift, Leipzig, 1906.
[10] *München. med. Wchnschr.*, 1907, 54, p. 1926.
[11] *Lancet*, 1913, 1, p. 1728.
[12] *Jour. Cutan. Dis.*, 1914, 32, p. 216.

It may be relevant to note that observers should be able to distinguish between brownian movement about a mean position and the motion exhibited by active living cell processes—either attached or free.

STRUCTURAL CHANGES IN ERYTHROCYTES

A photomicrograph of a living human erythrocyte with several processes is shown in Figure 2, Plate 2. The long process showed typical flagellum-like movement just before the exposure for the photomicrograph was made. The short processes on the same erythrocyte were not well brought out on account of their rapid movement. A red cell with such processes may be actually slowly free-swimming. The processes observed on the erythrocytes of birds, turtles, frogs, and fishes were particularly long and beautiful. As many as fifteen short processes have been seen in one focal plane on a human erythrocyte. Nucleated red cells usually have from one to four very clear or hyaline processes. The protrusion and retraction of the processes have been observed for both nucleated and non-nucleated red corpuscles. Occasionally a long process is completely retracted in much less than a second.

Certain peculiar redistribution phenomena, which occur in sealed preparations of red corpuscles of all classes of vertebrates, are worthy of a brief description. Such structures as granules, rings, curved rods, and undulating filaments, have been seen in the red cells of all vertebrates below mammals. Even the nuclear substance may change its distribution. Changes of the same order, but much less marked, are common in sealed preparations of human red cells. Granules frequently separate out of the corpuscular jelly, and notable changes occur in the distribution and density of the surface layers.

THE CONDITIONS UNDER WHICH VERTEBRATE BLOOD-CELLS UNDERGO STRUCTURAL TRANSFORMATIONS

The conditions under which cell-processes are put out have proved very variable. Human and rabbit white blood-cells, which have remained at room temperature from one and one-half to two hours after removal from the body, usually show all the phases that I have described, when examined in sealed preparations by dark field illumination, at either incubator or room temperature. The change from body to room temperatures seems to have a peculiar effect on the white cells of birds and mammals. For the first one or two hours after removal from the body, these cells are usually either inactive or show only ameboid movement and the hyaline surface phase. Incubator temperature may greatly shorten the time of appearance of processes. White blood-cells with processes have been observed in pieces of living tubercles from mouse lung; in exudates from corneal tubercles; in the mesenteries of frogs, which had been exposed to the air for several hours; and in samples of pus.

Very little has been made out about the precise conditions under which mammalian red corpuscles and nucleated erythrocytes of the other classes of vertebrates extrude processes. Human red corpuscles at room temperature do not usually show processes for some hours. In one preparation of human blood, kept at room temperature for about four hours, almost every red corpuscle had a single long undulating process. In the course of a thirty-minute observation many of the processes were retracted. The nucleated red cells of pigeons, turtles, frogs, and fishes, when mounted and sealed, and kept at room temperature, showed processes in from three hours to two days or even longer. Many human and nucleated red cells with undulating processes, which had lost their hemaglobin and were almost invisible, were observed. Certainly both nucleated and non-nucleated red corpuscles may be very active after all visible hemaglobin is lost. A decrease in oxygen tension appears to be a factor of some importance in the production of transformations in white and red blood-cells. I have recently succeeded in demonstrating the presence of numerous processes on white blood-cells which were mounted in shallow drops in a moist chamber and left for one hour at room temperature and then subjected to a temperature of 0 C. and fixed at this temperature with osmic vapor.

THE EFFECT OF LOW OXYGEN PRESSURE ON THE ACTIVITY OF BLOOD-CELLS

An extensive usage of sealed preparations has brought out the important fact that the white and red cells of vertebrates have the power of adjusting their metabolism to very low partial pressures of oxygen and even to anaerobic conditions. Very active red and white cells have been observed in sealed preparations kept at room temperature for three days.

THE RELATION OF STRUCTURAL CHANGES IN LEUKOCYTES TO PHAGOCYTOSIS

A number of experiments have been made with the aim of gaining if possible a clearer insight into the mechanism of the phagocytosis of bacteria by leukocytes and of determining the exact form taken by leukocytes in conditions similar to those of the usual in-vitro methods of studying phagocytosis. The results are of considerable interest. Leukocytes prepared according to the opsonic technic, mounted and sealed, and examined on a dark field in a microscope incubator, usually show the hyaline surface change in from ten to twenty minutes. White blood-cells in this phase frequently exhibit a rapid oscillatory flowing of parts of the surface jelly. The movement of globules in this layer has been frequently misinterpreted by previous observers and considered brownian movement. Leukocytes with numerous moving processes have been observed in such preparations in less than ten minutes after their removal to the incubator. The addition of emulsions of staphylococci to leukocytes does not change their behavior in any way that I could determine. In preparations of mixtures of motile bacteria and white blood-cells containing ciliated or flagellated forms, the actual entanglement of the bacteria by the processes was observed a great number of times. Occasionally the violent struggle of a bacterium resulted in freeing it from the leukocyte instead of more thoroughly imbedding it in the surfaces of the processes, as usually seemed to be the case. Further, the results of all my experiments on in-vitro phagocytosis point to the varying viscidity of the surface layers of the white cells as a fundamental factor in the fixing of bacteria to their surfaces. The oscillatory flowing of parts of the cytoplasm may well prove to be capable of carrying bacteria into the deeper layers of the leukocyte.

Finally it seems well to emphasize some of the optical difficulties which have been met in the course of this investigation. It is a well-known principle of physical optics that transparent bodies, which have the same refractive index and dispersive power as the mounting medium, are invisible when viewed by transmitted light. This important optical principle holds for many of the structural changes in blood-cells that I have described. Redistribution of the globular substance is about all that can be seen with achromatic objectives and uncorrected condensers. With the notable exception of cilium- and flagellum-like processes, about all the structural transformations may be observed by transmitted light with the optical system described above.

All the structural changes in blood-cells that I have figured or described may be observed with dark field illumination, yet this method has only a qualitative value. Processes on the upper and lower surfaces of cells are usually invisible. The long hyaline processes are likewise invisible unless the background is intensely black and they lie well within the focal plane. Another serious limitation of dark field illumination is the frequent failure of this optical method to bring out the exact structural relations of rapidly moving processes to the cell body. This particular limitation seems to be general, since an examination of numerous ciliates and flagellates gave similar results.

I am indebted to Dr. Paul A. Lewis for helpful criticisms and to Prof. C. E. McClung for the photographs.

EXPLANATION OF PLATE 2

Fig. 1.—Photomicrograph of blood-cells from a case of myelogenous leukemia.

Blood-cells prepared by the hirudin method, and fixed wet, at about 0° C. with osmic vapor and stained with iron hematoxylin. Myelocyte showing three long delicate processes. Magnified about 1000 diameters.

Fig. 2.—Photomicrograph of living human erythrocytes on dark field.

An erythrocyte with one long and several short processes.
Magnified about 1000 diameters.

Fig. 3.—Drawing of myelocytes.

a=A large myelocyte covered with fine pseudopods; b=A medium-sized myelocyte with long delicate processes of the flagellum type. The granules on two of the processes are probably artefacts, as such structures were not observed in living, active myelocytes. The leukemic blood was prepared by the hirudin method and fixed wet, at low temperature, with osmic vapor and stained with iron hematoxylin.
Magnified about 750 diameters.

Plate 2

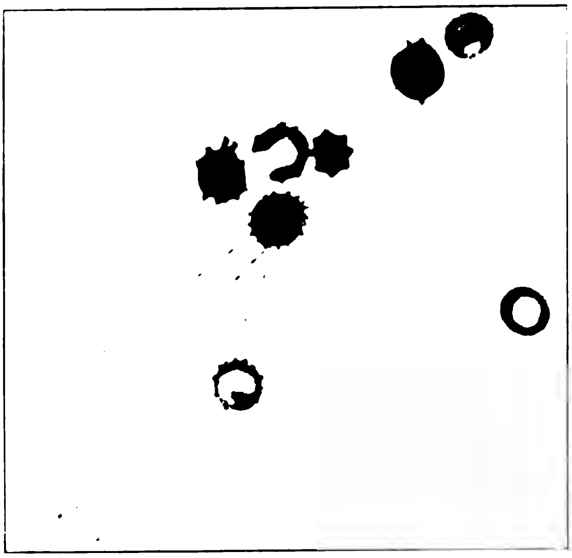
Figure 1

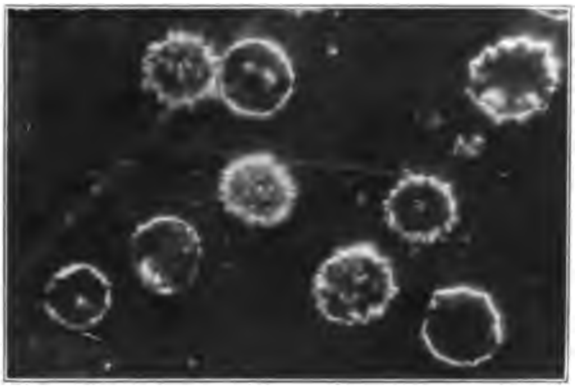
Figure 2

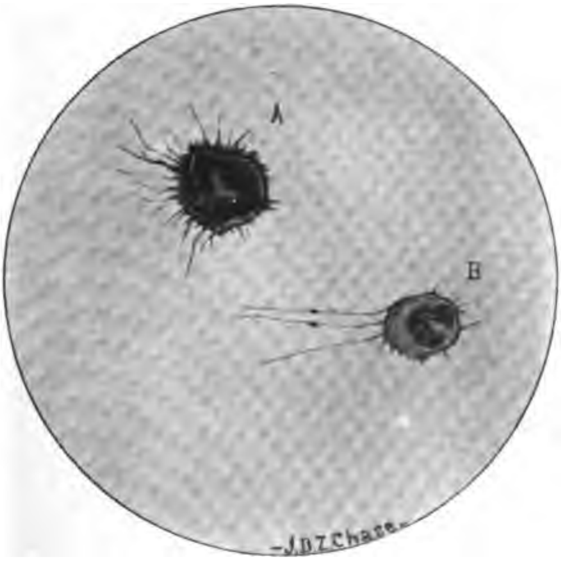

Figure 3

Medical Aspects of Pulmonary Surgery.

By H. R. M. LANDIS, M.D.,
Philadelphia.

(Read in the General Meeting of the Medical Society of the State of Pennsylvania, Scranton Session, September 26, 1912.)

Reprinted from Pennsylvania Medical Journal, April, 1913.

The past few years have brought about most important advances in the treatment of thoracic diseases. Certain affections of the lungs and pleuræ which were formerly treated symptomatically with no hope of cure have been brought within the scope of rational surgery. To a great extent this has been made possible by painstaking animal experimentation, and it is now an established fact that the technical difficulties which formerly stood in the way have been surmounted.

Diseases of the thoracic cavity, almost without exception come first under the observation of the internist, and it is his function to determine the existence of conditions which may be relieved or cured by operative methods, and not allowed to drift into hopeless chronicity.

Success in the treatment of certain of the affections of the lungs and pleuræ makes it essential that the internist should seek surgical advice in doubtful cases much earlier than is at present customary. On the other hand, it is equally essential that the surgeon should recognize that definite localization on the part of the clinician is not always possible, and that he must assume the responsibility of actually locating the trouble. While hasty operative interference is not to be recommended it must be remembered that the technical difficulties have been so far overcome that a positive diagnosis is not absolutely essential and that an exploratory operation is admissible. With a more general appreciation of the possibilities in this new field, it is not unlikely that much of the criticism, which at present involves the internist and surgeon alike, will cease.

That some of the diseases affecting the lungs and pleuræ can be more successfully treated by surgical methods must be apparent to any one who has followed the reports from some of the surgical clinics abroad and in this country. Furthermore, an infinitely greater experience in the treatment of certain of the inflammatory conditions of the lungs and pleuræ has pretty conclusively shown that little is to be expected from climatic, hygienic or medicinal methods.

Abscess. Of the conditions which especially demand surgical interference the first in importance are those due to suppuration. A pulmonary abscess, whether acute or chronic, is as certainly a surgical condition as an abscess in any other region of the body; and while a pulmonary abscess often spontaneously evacuates itself and heals, a too strict adherence to the expectant method of treatment is not advisable if the drainage is intermittent, the sputum becomes fetid or evidences of toxic absorption develop. Undue delay in seeking surgical assistance may also lead to rupture of the abscess into the pleural cavity with a resulting empyema.

Of thirty cases in the Boston City Hospital, with a diagnosis of probable pulmonary abscess, Jackson[1] reports that nineteen of the patients died, four were discharged unrelieved and seven were discharged relieved but not cured. These results are more discouraging when contrasted with thirty-seven pneumotomies done by Körte[2] for abscess and gangrene with twenty-five cures and twelve deaths. Kulps[2] at the same time reported twenty-three cases of pulmonary abscess from Quincke's Clinic, in which thirteen of the patients were cured, four were improved and six died. While it is freely admitted that the figures quoted are not sufficiently large to draw sweeping conclusions, they serve to emphasize what is pretty generally believed by those seeing very many cases of this type, namely, that surgery is the only certain method of relief.

Abscess of the lung may be acute or chronic, and is almost invariably secondary to other diseases. Acute abscess is most frequently seen as a sequel to croupous or bronchial pneumonia, septic processes in the mouth, pharynx or neck, and postpartum infection. In the majority of cases the presence of an abscess is to be suspected by the hectic fever, occasional chills and the persistence of pulmonary consolidation. The diagnosis is rarely made, however, until the appearance of the sputum. This constitutes the characteristic feature. The sputum appears suddenly, is puriform and usually copious in amount. In the beginning it may be brownish in color or, as is not uncommonly the case, grass green in color. Elastic fibers may or may not be present. With the evacuation of the pus, cavity signs may be recognized. A common site for abscess is at or near the inferior angle of the scapula. While patients do recover under expectant treatment, surgical advice should be obtained as soon as the abscess is recognized or, for that matter, even suspected. The question as to the advisability of surgical intervention should then rest with the surgeon.

Gangrene of the lung which occurs under somewhat similar circumstances is subject to the same rules.

Chronic abscess is less well understood than the acute form. The etiology is often obscure and the physical signs and symptoms are not distinctive. Of six cases of suspected chronic abscess seen at the Phipps Institute during the past eighteen months the patients each had a cough, which had persisted for months, and purulent sputum which did not contain tubercle bacilli. The constitutional disturbance was slight and the general health fairly good. These patients were all sent to the dispensary because they were supposed to be tuberculous. The physical signs were those of pulmonary consolidation at the base of one lung (poor expansion, impaired percussion note, feeble breath sounds and râles). In two instances an *x*-ray examination indicated the probable existence of an abscess.

In this connection it may be mentioned that in the majority of cases of nontuberculous infections of the lungs the trouble is situated at the base rather than at the apex of the lung; tuberculosis, as is well known, almost invariably starting at the apex.

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[1] Musser and Kelly: Practical Treatment, Vol. III.

[2] *Berliner Klin. Wochenschr.*, Feb., 1912.

One other point regarding small collections of pus either in the lung itself or encysted between the two layers of the pleura, is that one negative, or even a half a dozen negative needle punctures mean nothing. Often the abscess is so small that even repeated punctures fail to strike it.

While the individual's life is not especially threatened by a small chronic abscess, the condition if allowed to remain acts as a foreign body and is apt to lead to extensive fibroid changes in the surrounding pulmonary tissue and the eventual dilatation of the bronchi.

Encapsulated empyema, a term applied to a collection of pus between two visceral layers of the pleura, in an interlobar fissure or between the visceral and parietal layers of the pleura, is also subject to the same treatment as abscess. A common site for this condition is in the interlobar fissure near the angle of the scapula. Robinson is of the belief that in many instances what seems to be an encapsulated empyema is in reality a pulmonary abscess that has ruptured into the pleura and become encysted. The physical signs are practically the same as in chronic abscess. In some instances the affected area is sharply defined by localized tenderness to pressure on the thoracic wall.

Empyema. The most essential thing to keep in mind regarding empyema is that its successful treatment depends almost entirely on its early recognition. If after the crisis in pneumonia there is a chill and a recurrence of fever, the existence of an empyema should be suspected. Empyema may also occur as a complication of the acute infections, from an abscess of the lung or mediastinum rupturing into the pleural cavity, and as a result of injury to the chest wall. If purulent fluid in the pleural cavity is recognized within the first week or ten days of its development and receives prompt surgical treatment the results are, as a rule, excellent. After the acute stage is passed there is always some uncertainty as to whether the lung can be restored to its full functional capacity, as adhesions have had time to form and the extent to which these adhesions can be broken can only be determined by resection of several ribs and digital exploration.

If the empyema remains unrecognized for over six weeks or two months or has been insufficiently drained in the acute or subacute stages, the condition passes into the chronic stage. By this time the adhesions are so dense that in order to effect a cure recourse must be had to one of the major operations devised for this condition.

Bronchiectasis is practically always a secondary condition due either to long-standing bronchial inflammation or, what is more common, bronchial inflammation associated with pulmonary inflammation and induration. The condition develops slowly and is rarely recognized until well established. For this reason successful treatment consists in the relief of inflammatory conditions which are especially apt to produce indurative changes in the lung, notably chronic abscess and empyema.

The principal symptoms of bronchiectasis are dyspnea, a paroxysmal cough, and the expectoration of large quantities of sputa at variable intervals. If the sputum is fetid, and it often is horribly so, the lot of the individual is most distressing.

Associated as the condition is with fibroid changes in the lung the dilated bronchi are usually most marked about the root and base of the lung; the common sites of pulmonary fibrosis. The only exception to this is in tuberculosis where the bronchi at the apex of the lung are not uncommonly affected.

The physical signs are not distinctive. Poor expansion, some retraction of the chest wall, impairment of the percussion note, feeble breath sounds and cavity signs are among the signs which may be noted. Clubbing of the fingers is more extreme in this condition than in any other with the possible exception of congenital heart disease. The presence of extreme clubbing should always arouse one's suspicions as to its presence.

I have never seen a case of bronchiectasis much benefited by hygienic measures aside from a slight improvement in the general health. Drug therapy is also unavailing either in removing the trouble or in materially alleviating the symptoms.

Surgery is the only hope of relief, and this is not applicable if the disease is bilateral or involves one entire lung. If, however, the diseased area involves all or part of a lower lobe, an operation may be advised. Three methods are available: (1) Compression of the affected lung by means of nitrogen gas; this is not applicable in many cases owing to the dense pleuritic adhesions which so commonly accompany the condition. (2) Immobilization by means of extensive resection of the ribs overlying the diseased area. (3) Excision of the affected portion of the lung. Robinson[3] is of the belief that the latter procedure will be the eventual method of choice. He has reported a case of successful excision of half of the left lower lobe for bronchiectasis. Eight other successful pneumotomies for this purpose are mentioned by Fraenkel and Körte[2] in a recent article.

Pulmonary Tuberculosis. With the perfection of a technic for the performance of operation on the thoracic viscera, it is not surprising that surgeons have turned their attention to pulmonary tuberculosis. The simplest procedure and the only one which at the present time can be favorably considered is the production of an artificial pneumothorax. The operation is easy and, so far as can be judged from the results published, bids fair to become an established method in the treatment of a certain type of cases.

The production of an artificial pneumothorax is not to be recommended in cases with incipient or moderately advanced tuberculosis, if an arrest of the disease is being brought about by the usual hygienic and dietetic measures now employed. Robinson and Floyd[4] advise pneumothorax therapy in that group of cases advanced beyond the promise of relief of methods of hygiene, and before the disease has advanced to the stage when a fatal termination may be expected at any time.

Patients with frequently recurring attacks of hemoptysis have been markedly benefited by the production of an artificial pneumothorax. The operation is also admissible at times in hopeless cases for the alleviation of symptoms. The other operative procedures for the relief of tuberculosis involve the resection of a portion of one or all the ribs on one side. In some instances the operation is quite extensive. The number so far operated on is too small to form a judgment as to how permanent a place this procedure will eventually have in healing the disease. All that can be said at present is that even advanced cases of pulmonary tuberculosis stand operative interference surprisingly well, the immediate mortality in sixty-two cases operated on by Sauerbruch,[5] Wilms[6] and Friedrich[6] being fourteen and eight-tenths per cent.

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[3] *Boston Med. and Surg. Jour.*, Vol. CLIX.
[4] *Archives of Int. Med.*, Apr. 15, 1912.

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TUBERCULOSIS AND PUBLIC HEALTH

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We are now entering the second decade of the modern crusade against tuberculosis, and it may not be amiss at this time to look back over the work of the past ten years and see where we may improve our plan of attack.

The value of sanatoria and dispensaries cannot be gainsaid, and it is desirable that more of these institutions be established wherever needed. Furthermore, there is urgent need of sufficient beds to accommodate advanced cases, quite as much for humanitarian as for preventive purposes. All these agencies are indispensable for the proper handling of the tuberculosis problem.

Until a specific cure is forthcoming, however, the solution of the tuberculosis problem unmistakably lies in the prevention of new cases, and not in the treatment of these cases as they develop year by year. Unquestionably, many individuals have had their disease arrested, and a great many more have had their lives prolonged as the result of modern methods of treatment, but our present methods are defensive for the most part, and only preventive to a slight degree.

That the tuberculosis problem is a special problem, so far as treatment is concerned, is largely true; so, too, is the conservation of infant life and the treatment of mental deficients. These problems, and many others, are, however, so inextricably interwoven and dependent on the same underlying causes that the attacking of each one as a separate and distinct unit must of necessity lead to much wasted effort.

Vital statistics show us that the death-rates for most diseases in the slums of our cities and towns are in excess of other sections of the same cities or towns, and that poverty, ignorance, immorality, unsanitary habitations, carelessness, filth, and improper or insufficient food are all contributory factors. Therefore, anything that is done toward bettering the conditions in the slum tends to relieve, to a greater or lesser degree, all the evils which flourish in these unsanitary areas. Reduced to the last analysis, we really have to do with public hygiene and sanitation, which have as their chief objects the prevention of disease.

The material of the Phipps Institute is drawn from a restricted area, which is for the most part a slum, and the population is largely foreign born. In order that I may more clearly indicate the various phases of the tuberculosis problem and its relationship to public health I wish to submit the following facts obtained from an analysis of 100 consecutive cases.

The nativity was as follows:

Russian Jew	66
Italian	14
Irish	8
German	4
Slav	2
Native-born American	6

Eighty-seven of these patients lived in unsanitary houses; 50 were in addition uncleanly in their housekeeping; and in 9 instances the morals were bad. Of the 87 with unsanitary surroundings, one or all of the following faults were noted: No underdrainage; privy foul and full; one privy for from 4 to 8 families; alley or street in filthy condition; yard full of decaying refuse; ventilation insufficient; living rooms dark; and stagnant water in cellar. In 2 instances chickens were kept in the house. There were but 7 families in this group of which it could be said that the sanitary surroundings and the household hygiene were satisfactory.

In 60 families the income was inadequate. The sanitary surroundings were satisfactory in but 6 of this group, but in 19 more the household hygiene was good, even amid unsanitary surroundings. In the remaining 40 families the income was sufficient, but in spite of this, 35 were either living in unsanitary surroundings, were unhygienic in their housekeeping, or both.

The immigrant problem is one of the most serious which confronts the student of public health. The question of whether unrestricted immigration is advisable is beyond the scope of this paper. What does concern us, however, is how we are to bring about and maintain a higher standard of living among these people. This is necessary quite as much for our own protection as from any sense of duty we may owe them. The recently arrived immigrant, especially if he is of a non-English-speaking race, is only too frequently ignorant, poor, and with a low standard of living; he is usually found in the worst houses which our cities afford. "More than that, he not only lives in the worst houses, but in the worst districts of our cities, speaking from a sanitary viewpoint, and, as if this were not enough, coupled with the unfair treatment which his adopted city gives him in the form of wretched housing and squalid streets, his wife, unused to the living conditions into which she finds herself thrust, is likely to be none too successful in her efforts to cope with the situation, and her housekeeping is often far from sanitary, according to the standards necessary for urban health."*

Most of the above criticism applies with equal force to the negro population of our cities.

The housing problem, or, more properly, the home problem, because it includes not only the house itself, but the sanitary conditions within and without the house, and in addition the moral influences, is deserving of the most serious consideration. It is in the home for the most part that the entire drama of life is played; it is the very foundation and corner-stone of society, and should be particularly guarded against anything that tends to impair either the health or the morals of our future citizens.

"Infant mortality," Newsholme writes, "is always highest in crowded centers of population, but a high infant mortality can (by proper measures as to sanitation and housing) be avoided even under the conditions of dense aggregation of population."

The most important conclusion reached by the Philadelphia Vice Commission in a report, recently issued, was that "vice is chiefly a family and community, and not an individual, responsibility."

The relationship which the home bears to tuberculosis is too well known to require anything more than passing mention. As Koch said, "Tuberculosis has been frankly and justly called a dwelling disease." This fact has long been accepted, and yet we have contented ourselves, for the most part, with removing the patient temporarily from unsanitary surroundings for the purpose of treatment, and then allowing him to return to his unsanitary living conditions. In this connection it might be mentioned that of 36 ex-sanatorium cases recently investigated by the Social Service Department of the Phipps Institute, 16 were living in as bad, if not worse, conditions as before they went to the sanatorium.

If an individual can be treated successfully in the home, providing he adopts sanitary methods of living, why, one asks, has this principle not been applied more widely as a preventive measure? Newsholme, in commenting on this phase of prevention, states that "No preventive measures can be regarded as efficient and complete which do not vigorously attack and remove housing defects."

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* Women and Child Wage Earners, vol. viii.

The realization that the unsanitary house is one of the most potent factors in causing disease has led, within the past few years, to the formation of commissions and associations for the correction of this evil. For the most part such organizations are independent of the boards of health instead of being, as they should be, a part of their equipment. That this awakening to the necessity of improvement in housing conditions is a most hopeful sign, and one that promises much for future betterment, I am confident, but that it will entirely solve the problem I am not so certain. So far as my observation goes, a high premium is being put on the building of model houses, and little or no emphasis is placed on the methods of living by the people themselves.

I have come to believe that the most ideal housing conditions imaginable can be created, and that in a comparatively short space of time people will revert, so far as changed conditions will permit, to their former state of unsanitary housekeeping.

Bearing on this point, the judgment of the Edinburgh School Union, in its report for 1904, is of interest. "Our experience, lasting now over a period of eighteen years, reduces the housing problem to a question of management. We have come to think that a badly constructed house, well and efficiently managed, can be much less of a slum than one where there is no control, be it ever so well equipped. The problem, as we now see it, lies in the people and not in the houses. That the houses of our laboring classes should come to mean *homes*—that they should be clean and fresh and full of light and sweetness—we should all desire, but experience has taught us that in order to bring this to pass the people must desire it also. It is not even enough, nor is it possible, to remove them to modern well-built houses, with all the most modern sanitary conveniences. The change is too sudden. The modern improvements they do not appreciate and do not know how to employ. It is necessary to go to them where they are and as they are, and then teach them order and cleanliness, and the love of fresh air and a knowledge of the uses and preparation of food. Of what possible use is an oven grate to a person whose only food is tea and bread, with an occasional herring or a boiled egg? It is only by degrees, and one by one, that in such matters improvements can be effected. To attack the problem in the mass is, we think, a mistake. Each family must be treated by itself, and its members must learn for themselves, that while we as landlords have awakened to a new sense of our duties and responsibilities toward them, they on their side as citizens, as well as tenants, have very distinct and very definite duties and responsibilities, which they must also realize and perform." At the present time the Phipps Institute is conducting an experiment along these lines.

I have in this study selected $750 per annum as the minimum income for a family of five, consisting of husband, wife, and three non-wage-earning children. What constitutes an adequate income is one of the most vexed problems we have to deal with. And this is largely brought about by the extraordinary variations in the thrift of different individuals. Why one family does well on an income that is apparently too slender for its needs, and another is undernourished and exists amid filth with an income two or even three times as large, is one of the difficulties which confront us. As has been already noted, of the 100 consecutive families investigated, 40 had an adequate income, and yet of this number 35 were either poorly housed, unhygienic in their living, or both. On the other hand, 19 families out of the 60 with an inadequate income were cleanly in their household hygiene.

Can we remedy these evils, or is the task too great? Until within a comparatively few years it would have been difficult to advance a convincing argument that would meet the objections of the pessimist. Fortunately, we can point to an experiment in public hygiene which has proved successful, even under the most difficult conditions.

For centuries men dreamed of a Panama Canal, and as discovery after discovery opened up new lands and new sources of wealth, the demands of commerce became more and more insistent that this dream must become realized. Now it is practically an accomplished fact, and the world marvels at the engineering skill which made it possible. But, was it altogether engineering skill? That the French possessed the requisite engineering ability is admitted; that they were hampered by insufficient money is also known; and what is equally appreciated is that even though many times the sum needed had been forthcoming, failure would have been, in all probability, their lot. Today we realize why the French failed, and why, regardless of the financial scandal which attended their effort, failure would just as certainly have occurred.

The development of medical knowledge and sanitary science has more than anything else made the Panama Canal a reality. It is not necessary to go into the details of how one of the most notorious pest-holes known was transformed into a region safe for human habitation; nor need we dwell on the triumph which modern medicine has achieved over malaria and yellow fever. What is of immediate concern to us all, however, are the humble tasks performed by the sanitary corps in revolutionizing the living conditions, not in the small villages in the Canal Zone alone, but in the two old, unsanitary towns of Colon and Panama. Aside from the preventive measures employed against malaria and yellow fever, and the maintenance of a large shipping quarantine, the remainder of their work is of the most vital interest to every community in the United States.

What has been done in the towns of Colon and Panama should be done in many of our northern cities. Streets have been paved, and what is equally important, kept clean; underdrainage installed; pure water supplied; yards kept free from filth and rubbish; housing conditions improved; the fly nuisance abated; and the public markets supervised.

It is now well known that the morbidity and mortality returns from the Isthmus compare favorably with those of communities situated in the most salubrious climates. And this holds true not alone for the healthy laboring force, but for the natives habituated for generations to unsanitary surroundings and methods of living. That this has been accomplished simply by bringing about the reforms above mentioned no one can for a moment believe. The important factor has been the sanitary policing, backed by the authority to enforce any infringement of the laws which provide for the protection of the public health. Without this authority and the right to provide penalties it is doubtful if the high level of sanitary efficiency could have been maintained. It is this latter feature of public health work that we must take to heart if the slums of our cities are to be made even reasonably clean and kept so.

The tremendous importance of public health work must become apparent to any one who is at all familiar with what our government's medical officers have accomplished in the tropics. Their work has created a new field in medicine, the economic and social significance of which is but just beginning to be realized. It is incredible that any one who has any conception of the suffering, inefficiency, and enormous waste to society resulting from preventable disease and unsanitary conditions of living and work can fail to appreciate the great benefits that would accrue from a more active campaign against these evils. While it cannot but be a great source of satisfaction to us, as a nation, to point to what has been done for public health in our island possessions and on the Isthmus of Panama, we must realize that we are but poorly organized for scientific and practical sanitary work here at home.

The high standard of efficiency which has been set at Panama, for example, cannot be attained until the general public and our legislators are brought to a realization of the urgent necessity of sanitary reforms, and until the medical profession provides men properly equipped to perform the work. It is unfortunate, but nevertheless true, that the rank and file of the medical profession are but little interested in public health matters, and yet, as Wesbrook* has recently pointed out, "no official public health protective mechanism can operate without the intelligent interest and the sympathetic support of the medical profession."

In order that public health matters shall be properly administered we must have:

(1) The enactment of laws which will prohibit, or correct, conditions prejudicial to health, and the right to impose penalties for the infringement of these laws.

(2) We must provide, in our medical schools, for the proper education of physicians in public health work, and abandon our present hit-or-miss policy of selecting men for this duty.

In the future the qualifications for public health positions must be special training and efficiency, and to men possessing these requirements we must be prepared to pay adequate salaries and to vest in them the necessary authority properly to perform their duties.

(3) Sooner or later every municipality will have to be equipped with sanitary police, whose duty it will be to maintain hygienic order and aid the people in attaining higher standards of living. Work of this kind should, I believe, be done, preferably, by women who have had courses both in nursing and in municipal health work.

Not until public health work is placed on the high plane its importance demands can we hope to diminish very appreciably some of the evils which at present afflict us.

*Jour. Amer. Med. Assoc., April 19, 1913.

SIGNED CONSENT TO A NECROPSY A CONDITION TO ADMISSION TO OUR HOSPITALS

A BRIEF ACCOUNT OF TEN YEARS' EXPERIENCE IN THE PHIPPS INSTITUTE OF PHILADELPHIA

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The following account has been written to show how one hospital has solved the problem of the need of American hospitals for more necropsies, discussed recently by Theodore C. Janeway.[1] Whether or not the plan of requiring a signed consent to a necropsy in case of death is feasible for all hospitals, I am not prepared to say. I do feel, however, that the plan can be adopted far more generally than is at present thought possible, if the medical profession as a whole will take a more active interest in the matter.

It is an undeniable fact that far too many of the attending physicians and surgeons in our hospitals are lukewarm in their attitude toward this question, while most physicians without hospital connections take little or no interest at all. For those who are interested both in the advancement of the art of medicine and in the more thorough equipment of our students, it is rather discouraging to learn from the figures quoted by Dr. Janeway that, with three or four exceptions, only from 4.8 to 24.5 per cent. of the dead in our institutions are examined post mortem. The handicap under which American investigators and teachers labor is made more apparent when it is realized that in Germany and Austria the percentage of necropsies ranges from 77 to 99.9; in England from 71.9 to 85.9, and in the two great hospitals of Montreal from 62 to 86.4. As Dr. Janeway has well said, there is "no factor at the moment which operates so strongly to discourage careful clinical investigation in the wards of our hospitals as the probability that for three-quarters of the patients studied, the results will be lost in the case of death by failure to secure an autopsy."

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[1] Janeway, Theodore C.: The Great Need of American Hospitals: More Autopsies, Mod. Hosp., October, 1913.

It was just this realization of the situation that led to the adoption of compulsory necropsies in the Phipps Institute at the time of its organization ten years ago. The first director, Dr. Lawrence F. Flick, realizing that the staff of the institute would have to be trained in the diagnosis of diseases of the chest, and that a thorough study of the pathology of tuberculosis was possible only through the performance of as many necropsies as possible, made admission to the wards of the institute conditional on the signing of a blank reading as follows:

> I, ———, being the nearest responsible relative of M ———, in consideration of treatment and care at the Henry Phipps Institute, for the Study, Treatment and Prevention of Tuberculosis, do hereby grant permission to the medical staff, in event of death at that institution, for a necropsy.
>
> I will also be responsible for the removal of the body.
>
> Witness .... Signed ....
> Address .... Address ....

The accompanying table shows the number of patients treated in the wards, the number of deaths and the number of necropsies.

HOSPITAL PATIENTS, DEATHS AND NECROPSIES

	In Hospital	Deaths	Necropsies
1903	 238	54	53
1904	 234	89	89
1905	 197	60	60
1906	 205	69	69
1907	 227	80	78
1908	 195	53	53
1909	 225	76	75
1910*	 108	51	49
1911	 122	40	38
1912	 121	42	40
	1,872	614	604 or 98.37 per cent.

* The decrease in the number of patients and necropsies is due to the fact that in the spring of 1910 the bed capacity of the institute was reduced from 52 to 24, with 2 emergency beds.

In the ten cases in which no necropsy was held, it may be said that the right to do it was not waived because of objections raised after the death of the patient. In but one instance was there any probability that the family would have tried to resist the institute in the exercise of its rights.

For the first seven years the institute maintained fifty-two beds for advanced cases only. In the spring of 1910, when it was transferred to the University of Pennsylvania, the number of beds was reduced to twenty-four with two emergency beds. Finally, when the new Phipps Institute was opened in May, 1913, but half the twenty-four beds were devoted to advanced cases, the other twelve being used for incipient cases.

Although there is little likelihood of any of the latter patients dying in the institute, the same requirement is exacted for admission to the incipient as to the advanced ward. Even in the case of patients admitted but for a few days for some special treatment the necropsy blank must be signed.

The question naturally arises: To what extent has the signing of the necropsy blank militated against persons entering the institute? With the possible exception of Jewish patients, it practically has had no influence whatever. While no record has been kept of families who refused to allow a relative to enter the institute on account of this requirement, I can safely say that the number of refusals has been negligible and that there has never been a time when there was not a waiting list.

11 South Twenty-First Street.

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JAUNDICE IN TUBERCULOSIS.

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Jaundice is caused by the presence of bile pigment in the blood. It is now acknowledged that the passage of the bile pigment is by way of the lymphatics into the thoracic duct and thus into the general circulation, and is always caused by some obstruction, whether extrahepatic or intrahepatic, to the normal flow of the bile. Rolleston divides jaundice into: "(1) Extrahepatic or 'obstructive' where there is a gross obstruction, usually involving the larger extrahepatic bile ducts, to the flow of bile along the bile ducts. (2) Toxemic, intrahepatic, or hemohepatogenous, where there is obstruction in the small intrahepatic bile ducts. The obstruction is due to cholangitis or inflammation of the minute ducts, depending upon the irritating effect of poisons derived from the blood circulating through the liver." In tuberculosis we find jaundice caused by both extrahepatic and intrahepatic obstruction to the flow of bile.

The extrahepatic cases have been caused by tuberculous glands in the portal fissure pressing upon the bile ducts. This is a rare condition, from the fact that the glands in the portal fissure receive the efferent lymphatic vessels conveying the lymph away from the liver and not those conveying lymph from the intestines and peritoneum. These glands become infected through the liver, which has become previously tuberculous from material brought by means of the portal vein from tuberculous intestines and peritoneum. Florand reported a case that had been jaundiced for two months. A diagnosis of obstruction of the gall duct by a calculus or neoplasm was made. Operation was performed, but the patient died of hemorrhage from the portal vein, due to injury in trying to remove a bunch of tuberculous glands that extended from the duodenum to the portal fissure of the liver. Hodenpyl reported a case of a colored man who had jaundice which the autopsy showed was caused by occlusion of the common duct by a mass of tuberculous lymph glands. Knight reported a case of a child, aged six years, who had increasing jaundice up to the day of death. The autopsy here also showed a mass of tuberculous lymph glands the size of a walnut in the transverse fissure of the liver and around the hepatic duct and portal veins. Köster reported a case of a three-year-old boy who had been jaundiced for two years. A little while before death the jaundice disappeared. At the autopsy there was found in the portal fissure a tuberculous gland that had become caseous and opened into the common bile duct.

The intrahepatic, toxemic, or hemohepatogenous cases of jaundice occur in those cases where there is tuberculosis of the liver itself. Tuberculosis of the the liver may manifest itself in three ways: (1) miliary tubercles, (2) solitary tubercles, and (3) tuberculous cirrhosis. It is only in the first two forms of tuberculosis of the liver that any cases of jaundice have been reported.

Miliary tubercles of the liver are of frequent occurrence. Arnold considered them almost a constant finding in cases of tuberculosis. Rosenberger found miliary tubercles in 83.8 per cent. of livers examined histologically. Simmond found them in 76 per cent. in adults, in 92 per cent. in children, and in 82 per cent. in general. Ullom in examining histologically 100 livers found miliary tubercles in 79. Rolleston puts the occurrence of miliary hepatic tubercles in fatal cases of ordinary pulmonary tuberculosis lower than 50 per cent. Miliary tubercles are found in the liver in cases of general miliary tuberculosis; in these cases the infection is carried by the hepatic artery; or they are found in cases of tuberculosis of the intestines and peritoneum, and in these cases the infection is carried by the portal vein. Ullom in the histological examination of 79 livers containing miliary tubercles found the position of the tubercles to be periportal 40 times, intra-acinal 17 times, and both periportal and intra-acinal 22 times. In 45 cases, examined especially to see the relationship between intestinal ulceration and miliary tuberculosis of the liver, 38 cases showed intestinal ulceration. In these 38 cases the tubercles were found periportal 26 times, intra-acinal 3 times, and both periportal and intra-acinal 9 times.

Although miliary tuberculosis of the liver is such a common finding in tuberculous cases, jaundice caused by it is rare. Rolleston states it to be so rare that it is a curiosity. In 570 autopsies performed upon patients dying of chronic pulmonary tuberculosis at the Henry Phipps Institute, there has been only 1 case of jaundice caused by miliary tuberculosis of the liver.

CASE 2252.—A white man, single, aged twenty years, was admitted to the wards on March 31, 1904. Both he and his father had been hard drinkers, and his father had died of phthisis three years before. He had been sick for six weeks before admission, having been treated at another hospital for typhoid fever. He complained of slight cough, moderate expectoration of a greenish-yellow color, constipation, and night sweats. Examination showed advanced disease of both lungs. The heart had a diffuse pulsation over the whole precordium. The second pulmonic was accentuated. No murmurs were heard, and the dulness was normal. The liver extended two finger breadths below the costal margin. The spleen was palpable one and a half finger breadths below the costal margin. The abdomen was distended. On May 5, the patient was slightly jaundiced, not pronounced, simply an icteroid hue. There was marked tenderness over the liver. By May 14 the icteroid hue was less marked. The patient died on June 24.

The autopsy showed tuberculosis of the lungs, with cavity formation, miliary tubercles, edema, pneumonia, and bronchiectasis; parenchymatous nephritis; enlarged mesenteric glands; small ulcer in the appendix; adhesive pleurisy; fatty liver; heart slightly enlarged, valves normal. The liver was enlarged, weighing, 1860 grams. It was of firm consistence, dark red in color, and had rounded edges. Microscopic examination showed a marked grade of congestion, with distention of the capillaries and characteristic miliary tubercles, with large giant cells, epithelioid and round cells, and caseation.

The other type of tuberculosis of the liver in which jaundice manifests itself is the solitary tubercle, which is classified in three ways: (1) conglomerate tubercle, (2) tuberculous cavities or bile duct tuberculosis, and (3) tuberculous abscess. Conglomerate tubercles are comparatively large caseous masses found in the liver. W. Hale White, discussing this condition, says that before these caseating masses break down they may, unless care is taken, be mistaken for nodules of lymphadenoma. These conglomerate tubercles undergo caseation, soften, and at times, when situated near the bile ducts, rupture into them leaving small cavities in the liver. Solitary tubercles, in whatever form they appear, are an extrenely rare type of tuberculosis of the liver. The writer has been unable to find in the literature a single case of conglomerate tubercles of the liver that showed jaundice. However, two such cases have occurred at the Phipps Institute.

Case 2662.—A white woman, aged forty years, was admitted to the wards of the Phipps Institute August 8, 1904. Her father died at the age of forty-five years of tuberculosis. Mother died at the age of thirty years in confinement. She had one brother and one sister living and well. Two sisters died young of some unknown cause. She had never been sick, but gave a history of excessive use of alcohol over a long period. In the last two years she had lost sixty pounds, and for the past six months had had a cough, worse at night, accompanied by a profuse yellow expectoration. She complained of pain in the lower anterior part of her right chest; dyspnea on exertion, attacks of hoarseness, lasting several days at a time; poor appetite; epigastric pain; distress after eating; constipation; passing blood in the stools; night sweats; slight edema of the ankles. Examination on admission showed an emaciated body, with a face of fairly good color. The heart was normal as well as the abdomen. The lungs showed infiltration of the upper part of the right upper lobe; consolidation, with some softening of the left upper lobe. On August 25 the liver was found slightly enlarged, edges hard, but smooth and not tender. On September 21 the patient was markedly jaundiced; the liver was slightly enlarged. Pressure in the epigastrium caused a great deal of pain. No mass could be felt. On September 26 blood examination showed erythrocytes, 3,840,000; leukocytes, 10,000. The blood was pale and coagulated slowly. The jaundice had become more marked. The conjunctivæ were of a bright yellow color. The whole body was now deeply jaundiced, and pain in the epigastric region was more marked. The liver was distinctly palpable, and the edges sharp and hard. The enlargement was more apparent in the left lobe. On October 1 the jaundice was intense, the abdomen flabby, and distended. There was some free fluid in the peritoneal cavity. Several purpuric spots appeared on the abdomen. From this time on the patient rapidly grew weaker, the jaundice being extreme, pain marked in the epigastrium, sordes on teeth and tongue, pulse weak and irregular, and she finlly died on October 7. The temperature varied between 98° and 101° to 103° until fifteen days before death, when it dropped below normal and so remained until the end. The pulse was between 100 and 120 to 130, and respiration ranged from 27 to 40.

The autopsy on October 8 showed ulcerated tuberculosis of the left lung, tuberculous pneumonia and edema of the right lung, miliary tuberculosis of the spleen, fatty infiltration of the heart, fatty kidneys, with tubercles. The peritoneum contained about 1000 c.c. of yellow, slightly turbid fluid. The liver was enlarged and weighed 2016 grams; dense and granular on the surface; edges were rounded; its color was pale; scattered throughout were numerous small yellowish-white areas of firm consistence, some few were coalesced. The bile duct was patulous. The gall-bladder was distended with fluid, glycerin-like in consistency. Microscopic appearance: Many caseous areas, containing no giant cells and surrounded by epithelioid and small round cells; there were also typical miliary tubercles containing giant cells. The caseous nodules corresponded to the yellowish-white nodules seen macroscopically, and they contained tubercle bacilli in their periphery. There was an increase in the amount of fibrous tissue.

Case 9808.—A white woman, single, aged forty-five years, was admitted to the wards of the Henry Phipps Institute August 19, 1911. Her father died at the age of sixty years of heart disease and her mother at the age of forty-five years, of dropsy. Four sisters died in childhood of unknown causes. She had two brothers living and well. In 1908 she had had an attack of typhoid fever, but otherwise her health had been good. She had lost about thirty pounds in the past four or five years, and for the past year had had a cough, worse at night, which was accompanied with profuse yellowish sputum. For the past year she had been dyspneic. Her appetite for some months had been poor, and occasionally she vomited. There had been constipation for the past eight months. She had had night sweats nearly every night for the past year. Examination showed advanced disease of both lungs and the outline of cardiac dulness enlarged. The liver was enlarged and extended below the costal margin. On January 23, 1912, there was noticed jaundice in the conjunctivæ. The jaundice increased, and in two days was marked over the whole body. The liver was markedly enlarged, reaching to the umbilicus. It was quite tender. The stools were loose and of a natural color. The patient was nervous and not clear mentally, She did not answer questions intelligently. The jaundice lessened a little until January 29, when it became a little more intense and then gradually decreased until February 10, the day before her death, when it became markedly increased. All this time the patient had a slight talkative delirium, with some delusions. The liver remained enlarged and tender, and at no time was bile found in the urine or feces. The temperature varied between 95° and 103°, the pulse between 90 and 120, and the respiration between 18 and 36.

The autopsy showed chronic pulmonary tuberculosis, chronic adhesive pleurisy, chronic tuberculous laryngitis, chronic pericarditis, with effusion, tuberculous enteritis and colitis, congenital cystic kidneys, and congestion of the spleen. The liver was enlarged, weighing 2300 grams. It was yellowish-brown in color, firm in consistency, and had well-marked, rather sharp edges. On section it was yellowish-brown in color, and there were seen numerous small yellow areas, fairly well-outlined, about 1.5 to 2 cm. in diameter, arranged in groups of four or five. Scattered in many places, closer and more numerous, were smaller areas about 1 mm. in diameter. They were poorly defined, raised above the surface, translucent, and gray. In many places the interlobular septum was thickened. Iodine test for amyloid was positive. The gall duct was patulous. The gall-bladder was normal in size, and contained a dirty reddish-brown, thick fluid.

Rolleston in discussing bile-duct tuberculosis states it is remarkable that jaundice is constantly absent, inasmuch as there is definite obstruction in at any rate some of the bile ducts. Bristowe found

12 cases of small tuberculous cavities of the liver in 167 cases of tuberculous ulceration of the intestines, but he makes no statement whether or not jaundice was present in any of them. Thayer has reported a case of tuberculous cavities of the liver which showed jaundice for a week, but cleared up some time before death. Warthin had a case of bile-duct tuberculosis which had intense jaundice for three months before death.

At times the solitary tubercles become secondarily infected with pyogenic microörganisms, soften down, and form abscesses. Mayo-Robson has reported a case of tuberculous abscess of the liver which was successfully operated on and made a complete recovery. He states that for three months prior to the operation the patient had a slight tendency to jaundice.

That jaundice is a rare condition in tuberculosis is admitted by almost all who have had any experience in tuberculosis. Warthin has had a most unusual experience. He states that 80 per cent. of his cases of acute general miliary tuberculosis of the typhoid form have shown a well-defined icterus, either slight, moderate, or well-marked in grade, and about the same percentage of cases of chronic tuberculosis ending in a general miliary metastasis have also shown the same occurrence of jaundice. The writer's experience at the Phipps Institute dealing with chronic pulmonary tuberculosis for the most part had been quite different. In 570 cases that have come to autopsy in that institution, there has been but 3 cases of icterus; the findings in these cases are reported above. In addition to these 3 cases that died in the institute there were 4 other cases (Nos, 379, 1155, 3495 and 4748) that have shown jaundice; 3 of them showed a slight grade of jaundice and 1 a distinct icterus. These 4 cases left the hospital before death, and, of course, we could not prove that the jaundice was due to a tuberculous condition of the liver. These 7 cases of jaundice are all that have occurred in 1748 cases that have been in the wards of the hospital from the time of its inception until February 1, 1912.

From such a small number of cases it is impossible to draw any conclusions, but taken in connection with cases reported in the literature they are suggestive: (1) Jaundice occurring in the course of chronic tuberculosis is probably due to some form of tuberculosis of the liver, either extrahepatic or intrahepatic. (2) The grade of the jaundice is helpful in surmising the pathological condition, intense jaundice being probably due either to pressure of tuberculous glands on the extrahepatic ducts or to some form of the solitary tubercles of the liver; milder forms being produced by a miliary tuberculosis of the liver.

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THE HEALTH ASPECTS OF THE CLOTHING INDUSTRY

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THIS study of the clothing industry was undertaken for the purpose of determining the true causes responsible for the general belief held that the rate of tuberculosis and of morbidity and mortality generally in this industry is excessive. Many employments by their nature predispose to ill health, the pathological results being shown in a higher morbidity from general diseases (as distinct from occupational diseases), particularly tuberculosis.

To determine, then, in the absence of official sickness statistics for this country, the actual amount of sickness, whether preventable or not, in this industry or in its different groups of trades or occupations, with information regarding the actual conditions under which it is carried on in Philadelphia, and the relation of such conditions to the longevity and sickness rates of the employees, becomes the object of this study.

As it is the first study of its kind undertaken, at least in so far as the method of relating the physical condition of the worker with the sanitary conditions of his living and working environment, it cannot be hoped that great headway will be made in ascertaining beyond a question the direct influences of trade upon physical condition. All that we can hope to do is to establish certain methods and lines of inquiry which may later be followed and amplified from other sources. It is also hoped that the present unsatisfactory state of our hospital and dispensary statistics, as well as the records of our local health departments, will be so organized as to make the study of occupational diseases possible along broad lines, and with a basis of comparison that is not at present available.

The multiplicity of factors which enter into a consideration of the present physical condition of the workers, aside from the hereditary tendencies, of which little of any value can be secured from a statement of the worker, either normal or with positive physical ailments, renders any study of occupational effects tentative. This is especially emphasized by the large problem that the investigator must encounter in securing comparative data which should be obtainable from the records of hospitals, dispensaries, and municipal departments of health, which, with legal powers and recording machinery, have the opportunity to render invaluable assistance to the study of occupational diseases on a scale leaving no doubt as to the etiological factors of occupation in relation to ill health.

The study undertaken by the Phipps Institute is an attempt to pave the way toward a more general co-ordination of the means and sources of information relating to occupational diseases, and the stimulating of co-operative methods of study in the community. If we succeed in doing nothing beyond pointing out the vast sources of information at our command, and the need for their utilization, we shall have served the cause of social and industrial hygiene.

This study includes nearly 1000 workers examined indiscriminately while at work. Of these, 743 were studied intensively—402 males and 341 females. It seemed best, in order to insure a representative group, to use the factory as the focal point, and for this purpose three distinct types were selected, namely, the modern standardized factory, the contracting factory, and the sweat-shop.

The homes and places of employment of these workers were studied separately with a view of ascertaining, in so far as possible, the influence of each factor, personal, environmental, and economic, and its bearing upon the health of the individual.

One of the most important factors in determining the physical conditions of workers as related to their occupation is to be found in the occupational history of the individual. The mere presence of an individual in a particular occupation, and the facts relating to his physical condition as revealed by a careful medical examination, are not conclusive proof of the influence of that occupation upon the physique, even though all other conditions surrounding the worker remain the same.

I. Taking up the various factors which may have a bearing on the subject, we have to consider, first, the working-place itself. In all, 45 places of employment were investigated, and in but 6 of these were hygienic conditions entirely satisfactory. Dirt, rubbage, and a general appearance of dilapidation were characteristic of the poorer places. While dust abounded in many of the shops, it cannot be considered as an inherent objection to the trade, as much, if not most, of it was the accumulation of weeks and even months, and such as might occur in any working-place, which was rarely, if ever, subjected to a regular cleaning.

Dust which may arise in the various processes incidental to manufacturing clothing is not a serious factor when compared to the amount of dust that occurs, for instance, in the manufacture of the cloth itself. And while it is not possible to dismiss the dust as met with in these places as a negligible factor, it is certainly not a very important one.

In regard to ventilation, 39 of the 45 shops investigated lacked proper facilities, although in some instances this may have been apparent rather than real, owing to the fact that the building was so old that it was impossible entirely to exclude the outside air. It is highly probable, however, that overheating and a lack of fresh air render the workers more than usually liable to "common colds" and respiratory disorders.

No less than 39 of the 45 shops were not equipped with proper toilet facilities. In 11 there was no provision made for the separation of the sexes; in 36 the toilets were unsanitary, and in 37 there were varying degrees of uncleanliness.

In considering the working-place, some mention must be made of the great risk to which the workers were exposed to the danger of fire. In 20 of the 45 shops the fire-escapes were inadequate. In 43 the fire risk was serious by reason of the character of the building, even in those cases in which the fire-escapes could be considered as ample. In but 4 of the 45 shops was a fire-drill practised.

It seems apparent, therefore, that while the defects in the sanitary and hygienic conditions of the factories are measurable, the difficulty of tracing the effect of particular conditions upon the individual worker is not easy. This difficulty is especially increased by the tendency of the workers to shift from a good shop to a bad one, and vice versâ.

II. To show that this or that occupation is inherently harmful it is necessary to eliminate all factors which can in any way be considered as being contributory. This cannot be done unless we make a thorough study of all the circumstances relating to the worker's daily life. The danger of a bad working-place may be offset by excellent living conditions. On the other hand, the working-place may be ideal, while the home hygiene is as bad as possible. As more than half of the worker's time is spent in his home, the influence of unsanitary surroundings cannot be ignored. The following table indicates the hygienic conditions found on investigating the homes of these 402 male workers:

Clean	182 (45.3 per cent.)
Fair	119 (29.6 per cent.)
Dirty	101 (25.1 per cent.)

As this table shows, 25.1 per cent. were living in unhygienic surroundings, and in 29.6 per cent. the sanitary conditions were classed as fair only. While some of this latter group might be transferred to those classed as clean, it is equally true that the group designated as dirty might be further augmented.

Overcrowding in the home was not a marked factor, except in the case of the Lithuanians. The living conditions of this group were, taken as a whole, the worst we encountered, and were in no way related to their earning capacity. Furthermore, the free use of alcohol was especially prevalent among them.

It is thus apparent that one-quarter of the 402 males investigated were subject to bad sanitary surroundings in their home, a fact that cannot be ignored when we come to estimate the influence of the trade itself upon the health of the individual.

III. *Wages.*—Many garment-workers made good wages if one considers only the time they are actually employed, but if the periods of seasonal inactivity, amounting to from three to four months each year, are taken into account, the average for the entire year is low. Furthermore, the ability to make a large wage depends to a great extent on the rapidity with which the worker can accomplish his task. As most of them are paid by the piece, the earning capacity will, of necessity, vary for different individuals.

So far as this trade is concerned, the question of wage enters very strongly into the problem, for even where the wage is sufficient, it is frequently earned at the cost of tremendous energy. It is difficult to estimate the damage thus done, because of the fact that the deterioration in strength and health is gradual and cannot be readily measured.

IV. *Racial Characteristics.*—In estimating the effect of this particular trade on the health of the workers one must not lose sight of certain racial peculiarities. The great majority of the people studied by us were—(1) Jews, who comprised nearly three-quarters of the males; (2) Italians, principally women, and (3) a small group of Lithuanians. The Jew possesses a capacity to drive himself to the extreme limit of his endurance. He does this largely because of an ambition to better himself and to accumulate sufficient means to enable him to start in business for himself; and while but relatively few reach the goal of their ambition, the effort costs many of them their health.

The Italians, on the other hand, work easily, and while many of the women work overtime in the home, they rarely make any effort to drive themselves at top speed, as does the Jew; and the same is true of the phlegmatic Lithuanians.

V. Considering the health conditions prior to taking up the trade, only 2 out of the 402 male employes were in poor health; close inquiry showed that 29, or 7.2 per cent., had fair health, and that 371, or 92.3 per cent., were in good health. It is thus seen that nearly the entire group, so far as they knew, were free from any physical disability before entering the trade. It is furthermore of interest to note that the time spent in the trade was practically the same as the length of residence in the United States. This is important because, with few exceptions, there is no secondary employment to be considered as having a contributing effect on the production of ill health.

Of the 402 males examined, 51 had abnormal physical signs in the lungs. In considering the number in which signs indicative of tuberculosis were found it is to be borne in mind, however, that active tuberculosis was present in but two or three. The remainder simply had signs at one or the other apex, showing that changes had occurred which might be considered as being, in all probability, evidence of a latent or healed tuberculosis. To determine the number which were arrested and those in which the disease was actually beginning to manifest signs of activity would, of course, require that the suspected individual was carefully observed for several weeks at least. After all, one would not expect to encounter a very large number of individuals having active tuberculosis, for the reason that those studied represented a body of men and women at work and presumably in good health; and, furthermore, just as soon as the tuberculous infection advances sufficiently to impair the health, the individual usually stops work.

An analysis (not yet completed) of the occupations followed by the first 11,000 patients treated at the Phipps Institute shows a very considerable number who were employed in the garment-making trade. This is to a great extent explainable, however, by reason of the fact that about 85 per cent. of the people engaged in this trade are Jewish, and about 70 per cent. of the patients visiting the Phipps Institute are members of this race. It is not altogether surprising, therefore, that in the experience of this particular institution the garment-making industry is liberally represented among the occupations given by the patients.

Considering the various phases,—bad sanitation in the shop, bad sanitation in the home, a low wage, physical fatigue, and poor food,—we are forced to conclude that tuberculosis, when it does occur among garment-workers, is not peculiar to the trade *per se*, but is the result of a number of factors.

Gastro-intestinal disturbances, for the most part, indigestion and constipation, were very common occurrences. No less than 257, or 64.9 per cent., made some complaint of this sort. It is questionable, however, whether these complaints, usually more or less trivial in nature, were of any greater frequency than one would be apt to encounter in an unselected group occupying the same position in life. Headaches, some of them undoubtedly due to eye-strain, and pain resulting from faulty postures, were relatively common. The only condition we encountered which seemed to be directly associated with the occupation itself was a chronic inflammatory condition of the eyes. Chronic conjunctivitis was encountered in 43 of the 402 males, and 30 of those thus affected were pressers. The great frequency of this condition among pressers is apparently due to the character of their employment, as the frequency of inflammation of the eyes among the pressers is six-fold greater than in those otherwise employed in the industry.

The greater liability of the pressers seems to be due to one of three factors—the heat of the iron, the vapor which arises from the dampened cloth, or the fumes from the gas which is used to heat the irons.

In answer to the question, "Is the garment-making trade one that is of itself an occupation which is inimical to health?" we are forced to conclude that it is not. For the past two years a night tuberculosis class has been conducted at the Phipps Institute. This class was formed principally for the purpose of seeing whether garment-makers who had returned from sanatoria, or who had had to remain at work while continuing their treatment, could follow this trade without breaking down. As a result of this experiment it can be said that such individuals can follow the trade of garment-making providing they live under suitable hygienic conditions.

In conclusion, we would like to call attention to the necessity, in the study of any occupation, of taking into consideration all the factors which may lead to the deterioration of the individual's health. In some cases, as, for instance, exposure to lead and phosphorus, there can be no question as to the direct relationship which exists between cause and effect. On the other hand, there are many employments which are credited with being bad, but which in reality are not, much of the evil that is associated with them being the result of contributory factors which are not directly connected with the work itself. And to this group the garment-making industry seems to belong.

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THE DIAGNOSIS OF TUBERCULOSIS IN EARLY LIFE.[1]

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This paper has to do with the chronic form of pulmonary tuberculosis in children, and does not consider the acute manifestation of the disease, such as general miliary tuberculosis, tuberculous meningitis, or the acute bronchopneumonic form which complicates or follows some one of the acute infectious diseases; nor does it consider the surgical aspects of the disease. There are two reasons for this: In the first place, children suffering from the disease in any of the forms above mentioned usually are taken to the general hospitals and are rarely seen in a dispensary devoted exclusively to tuberculous patients, and in the second place, while individual cases may present difficulties in making a diagnosis, the clinical picture in the majority of cases of this type is usually readily recognized.

Excluding the types just mentioned the recognition of tuberculosis in children is either extremely easy or most difficult, the determination of a positive or negative finding depending almost entirely on the attitude of the particular observer. Thus, in some instances, all children having a tuberculous parent have been considered as being likewise tuberculous. In others the occurrence of a positive tuberculin reaction or the presence of palpable lymph nodes in the neck have been considered as sufficient evidence to designate the child as having tuberculosis.

The reason for the current belief that tuberculosis is an extremely common finding in children, particularly in children of the poorer classes, is largely due to the general acceptance of the theory that infection with tuberculosis is commonly acquired in childhood.

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[1] Read before the Philadelphia Pediatric Society, May 12, 1914.

That this is true in many, possibly the majority, of cases everyone agrees. That it is invariably the case, however, has not been proved. The theory that infection in childhood is the universal one, if it could be shown conclusively to be true, would at once dispel all the uncertainties regarding the etiology of the disease; and furthermore, it would change very radically our procedures in the way of prevention.

At first sight the etiology of tuberculosis seems perfectly clear. If, however, we analyze the subject more closely we are forced to admit that we know very little about it. This may seem to be putting the question too strongly; but let us examine some of the facts and see how matters stand. That infection with the tubercle bacillus is widespread, and, furthermore, that it commonly occurs early in life, is practically universally acknowledged. So far we stand on reasonably firm ground. When, however, we attempt to explain why relatively few of those thus infected develop tuberculosis which is clinically recognizable while the majority of infected individuals pass through life with no manfestations of the disease we can only hazard a surmise.

A number of factors must be considered—namely, the question of hereditary predisposition, the influence of race, poor food, bad housing conditions, overwork, mental worry, acute illness, dissipation, and, lastly, reinfection later in life. Anyone of these may be sufficient to lower the resistance of the individual to a point where the natural defences of the body can no longer keep in check the multiplication and spread of tubercle bacilli already within the body. It seems apparent, therefore, that while many children may receive an implantation early in life the determining factor as to whether they become openly tuberculous later in life is dependent on a number of factors, most of which have to do with unsanitary evils. For the most part the problem becomes one of a diagnosis of the social surroundings of the child rather than of its physical condition. It is, of course, understood that the same effort should be made with children as with adults to recognize those having true clinical tuberculosis.

The present study relates to 362 children examined at the Phipps Institute between three and four years ago. The majority of them were brought for examination because of tuberculosis in one or the other parent and not because the children themselves had any symptoms. Reports as to the condition of 111 of these children have been obtained within the past two or three months. The examination of these children was made by five men on the dispensary staff and a study of the records affords a good illustration of the points of view of different observers. Of the 362 a positive diagnosis of tuberculosis was made in 96 (26.5 per cent.). In studying the records the conviction cannot be escaped that this percentage is either too low or too high for the reason that many cases designated as non-tuberculous could readily be classed as having tuberculosis, and *vice versa*. In other words, undoubted evidence of tuberculosis was present in but a few; in the remainder the individual's point of view seemed to be the determining factor in making a positive or negative diagnosis. It might be well to mention at this point that of the 111 of these children recently heard from, 25 had a diagnosis of tuberculosis over three years ago. All of these children are reported as well except 2, 1 of whom recently died of tuberculosis and 1 of a cause unknown.

SYMPTOMS. The symptomatology of tuberculosis in adults, while subject to many vagaries, is invaluable in making a diagnosis. Indeed in many cases of incipient tuberculosis it is our chief reliance in determining the nature of the trouble. In children, on the other hand, we are deprived of much of the value of symptoms, because of the inability of young children to give a correct description of their trouble; and in the case of the present group the difficulty is augmented by reason of the fact that they are for the most part, the children of foreign parents, who, in many instances, are almost as useless as the children themselves so far as giving a history of the illness is concerned.

TEMPERATURE. One of the most reliable means of detecting early tuberculosis in the adult is the slight rise in temperature which may occur daily or only every few days. In children, however, little reliance can be placed in these slight elevations of temperature, for the reason that growing children normally have a higher temperature than adults. Landois[2] gives as the normal limits 99.5° to 100.1° F. (37.87° to 37.62° C.) in children from five to nine years; 190 of the 362 children had a temperature of from 99° to 100° F. The reason for this is, in all probability, a more active metabolism, although other influences of undetermined origin may also, in part, be contributory; 143 (31.3 per cent.) complained of cough. As a rule this was of but a few days' duration; 223 (61.6 per cent.) stated that there was no expectoration. The sputum of 37 was examined, with negative results. Hemoptysis was said to have occurred in 16. Chest pain was complained of in 95. Hoarseness of a transient character was noted in 48 and persistent hoarseness in 9. Night sweats occurred in 52.

Cough, if it has persisted for weeks, hemoptysis, and persistent hoarseness would have the same significance in the child as they do in the adult.

PHYSICAL SIGNS. In taking up the question of physical signs in the chests of infants and young children we have to consider what is probably the most difficult phase in the art of physical diagnosis. And while it is true that the underlying principles which enable us to detect disease in the chest are the same, whether it be adult or child, there are certain differences between the two which must be kept in mind. Generally speaking the man whose training has been confined to the examination of adults alone, or children alone, is likely to draw false conclusions when he invades one or the other field, and much that has been written regarding the presence of chronic tuberculous lesions in the lungs of children has been contributed by those whose standards have been obtained by the examination of adults with tuberculosis.

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[2] Text-book of Human Physiology, 10th ed., p. 391.

Furthermore, it must be borne in mind that the clinical forms of human tuberculosis in different ages possess correspondingly different anatomical features, a knowledge of which is necessary for the understanding of the interpretation of physical signs. In the majority of instances, tuberculosis, when it involves the lungs of infants and young children, is bilateral, widespread (either of the miliary or bronchopneumonic form), and acute in character.

In the adult, on the other hand, the disease begins at one or the other apex, follows a fairly definite course in its progress, and is chronic in character, although subject to periods of acute activity. As a rule the clinical manifestations of tuberculosis as they occur in infants and young children differ from the adult type, and this is not altered by the fact that the juvenile type may occur in adults, and *vice versa.*

It is not altogether easy to fix definitely the age period at which the signs peculiar to children cease. Some have arbitrarily fixed this limit at the age of six years, although in our judgment ten years would be more nearly correct.

Probably the most distinctive difference between the adult and the child is that in the latter all of the sounds are exaggerated. Not only is the breathing of the familiar puerile type, but all the vocal sounds are increased, and in addition the percussion note is commonly hyperresonant.

As an illustration of how the exaggeration of physiologically normal signs may be misinterpreted in the child it is interesting to note that of 79 children in this group who were charted as having abnormal physical signs no less than 67 had impairment and bronchovesicular breathing at the right apex. It will be recalled that in the adult the right apex normally has a slightly impaired note, prolonged expiration, and increased fremitus, and that the explanation of this was pointed out by Fetterolf[3] as being due to close proximity of the trachea to the right upper lobe. The very high proportion of cases in this group, with apparent disease at the right apex, would seem to indicate that what was in reality a normal finding was interpreted as being pathological.

One's belief in this is strengthened from the result of reports on 111 of these children three or four years after the first observation. Of these 111 cases 17 were noted as having a diseased right apex, and in 2 more both apices were supposed to be affected. At the present time 17 of the 19 are noted as being in good health, 1 has died of tuberculosis, and 1 still has some cough.

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[3] Archives of Internal Medicine.

In addition to the exaggeration of the breath sounds already noted the respiratory sounds in children are subject to a number of vagaries, and the younger the child the more difficult is the interpretation of the auscultatory signs.

The expired air may, for instance, be directed into the pharyngeal vault or against the roof of the mouth, with the result that a bronchial quality of breathing is heard all over the chest. This can be obviated if the child is old enough to learn how to breathe properly. Then again in young children and infants the lungs at times seem to move independently of one another, with the result that loud puerile breathing is heard over one side, while over the opposite side the breath sounds are almost inaudible, and this condition shifts from side to side. This peculiarity is often due to faulty posture. If care is not taken to see that the child sits straight, and that one or the other side is not held tense, not only will there be very faint or nearly absent breath sounds on the cramped side, but in addition the percussion note may be impaired, or indeed absolutely dull. We have often demonstrated this fact to students and shown them how the signs on the two sides can be almost instantly reversed. This fact is worth remembering, as the unwary may make a diagnosis of pneumonia or pleural effusion.

In adults one of the most valuable means of detecting early pathological changes at the apex is the restriction of expansion over the affected area. In children this procedure is almost useless, except in a few of the older ones, because of jerky movements, and what has seemed to us to be often the case, the fact that the lungs of infants and young children do not seem to possess the same synchronous movement that the adult organs possess.

LYMPH NODES. In nearly every article dealing with the diagnosis of tuberculosis in children great stress has been laid on the presence of palpably enlarged cervical lymph nodes. Indeed in not a few instances, in which surverys of large groups of children have been made, this apparently has been the only evidence on which the diagnosis was made. The fact has been ignored that the age of childhood is likewise known as the lymphoid age, and that all children, irrespective of their social condition, have lymph nodes which are readily palpable. The enlargement of the lymph nodes is not readily detected until about the second year, but from then on until shortly before or after the age of puberty this is the case, although as the child approaches adolescence certain groups, such as the epitrochlear, the axillary, and the inguinal, tend to shrink in size and become less easily detected. The submaxillary node at the angle of the jaw is usually the largest under normal conditions, and is usually the last to shrink to a size that it can no longer be palpated.

In our experience all of the superficial lymph nodes can be palpated readily in the majority of cases if the children are systematically examined from this standpoint.

To confine the examination to one group, such as the cervical, and because the nodes in this situation are palpable, to assume that it is an evidence of tuberculous infection does not seem in any way justifiable, especially so in view of the fact that all the lymph nodes of the body are hypertrophied according to adult standards.

If there exist in the neck a single large node or a tumor mass made up of a number of nodes, which are matted together and adherent to the surrounding tissues, the presumption is strong that we have to deal with a tuberculous adenitis, and especially so if there is evidence of softening, or the overlying skin is inflamed. This, however, is true scrofula, and has nothing to do with nodes which vary in size from that of a bean to a split pea, or smaller, which are freely movable, and which manifest neither softening nor inflammation.

Of the 362 children here reported the records show the following results: cervical, 250; submaxillary, 202; axillary, 209; epitrochlear, 94; inguinal, 212.

It is to be borne in mind that the above records are of positive value almost entirely, and that the discrepancies between the different groups are largely because the examination was not complete.

Still another group of lymph nodes must be considered, namely, the bronchial. Of recent years a great deal has been written on the physical signs and symptoms of tuberculous enlargement of this group, especially the former. Some writers have reported quite a high percentage of cases in which this condition existed. Much of the evidence on which such a diagnosis is made seems open to question, especially from the standpoint of physical signs. In our opinion the alleged percussion changes, such as the semilunar areas in the second and third interspaces anteriorly and the vertebral dulness posteriorly, which are supposed to be indicative of such enlargement, are fanciful rather than real, and the questionableness of such findings has been shown by Gittings and Fetterolf[4] in their work on frozen sections of the thoraces of infants and young children.

X-ray studies made by Pancoast of children in whom we suspected this condition might exist have given negative results in the majority of instances. The mere fact that these nodes may show some enlargement on x-ray examination is no proof that they are pathologically enlarged in view of the fact that we know all the superficial nodes are hypertrophied normally.

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[4] Some Anatomical Features of the Child's Thorax; Their Application in Physical Diagnosis, Amer. Jour. Dis. of Children, 1911, vol. i.

The truth of the matter is that this diagnosis is not easy. Children below par and who have a persistent hard, brassy cough, usually unproductive, seem to be the ones most likely to suffer from this condition.

In this connection it may not be amiss to say something regarding the tonsils, as they are regarded by many as portals of entry for the tubercle bacillus. Here again we are dealing with lymphoid tissue, which in children is excessive, and which, as the years pass, tends to shrink until the relatively large tonsil of the child is transposed to the atrophied one of old age. The removal of tonsils which are enormously enlarged, and which are associated with frequent colds, or inflammation of the tonsils themselves, is one thing, but the wholesale massacre of these organs simply because they are enlarged, according to adult standards, is in our opinion a mistake. Our records show that of 290 children examined from this standpoint 110 were noted as having some enlargement of the tonsils.

Mouth-breathing was noted in 144, although adenoids were detected in but 24. These latter figures are not trustworthy, however, as but a small percentage had a skilled nose and throat examination.

Teeth. While the condition of the teeth has no direct bearing on the diagnosis of tuberculosis in growing children it is coming to be recognized more and more that the general health of the child may be adversely affected by a large number of badly decayed teeth. Thus bad teeth may be one of the contributing factors in lowering the general resistance and permitting the latent tuberculous infection to gain the upper hand.

Of the 191 children examined as to the condition of their teeth, 48 were classed as good, 69 as fair (that is but two or three decayed teeth), and 74 as being very bad.

Tuberculin Tests. The accepted belief at the present time is that a positive reaction to one of the tuberculin tests is indicative of a tuberculous lesion somewhere within the body. A positive test does not mean, however, that the individual has clinical tuberculosis. It must clearly be kept in mind that there is a great difference between tuberculosis that is clinically recognizable and hypersensitiveness to tuberculin. Hypersensitiveness is extremely common, and is encountered in a large proportion of children, the frequency with which it is met increasing rapidly from the second to the fifteenth year. It is a great mistake to assume that because a child reacts to some one of the tuberculin tests that it is tuberculous in the sense that it needs active treatment; and, as we shall later point out, a negative tuberculin test does not entirely free us from responsibility.

In regard to the tests themselves there are certain facts which should be kept in mind. First as regards the subcutaneous test. This is rarely employed in children, especially the very young ones. At one time the test was extensively used in adults and a positive reaction was, and by many still is, regarded as conclusive proof that the individual has tuberculosis. Of recent years, however, some observers have warned against its use, pointing out that the test is capable, in certain instances, of stirring an inactive lesion into an active one. Furthermore, there is now a tendency not only to limit the use of the test, but in addition to ignore the constitutional symptoms of a reaction (such as fever, joint pains, local reaction, etc.) and to call positive only those cases which give a focal reaction, such as rales at a suspected apex, or some pain, redness, and swelling in a suspected joint.

The cutaneous or von Pirquet test has achieved enormous popularity by reason of its simplicity, and also because it is widely credited with being positive evidence of tuberculosis. In children under two years of age it is valuable evidence when positive and usually means clinical tuberculosis. Beyond the second year, however, it loses much of its positive value, and the older the child the more unreliable it is as an evidence of true tuberculosis.

The percutaneous or so-called Morro test has about the same significance.

Finally we have to consider the conjunctival test introduced by Wolf-Eisner and Calmette. The majority of observers have come to regard this test as dangerous, because of the possibility of producing an inflammatory condition which may lead to serious damage of the eye. According to Hamman and Wolman,[5] who have employed the test in a large series of cases, the test is free from danger, and is superior to the Morro and von Pirquet tests in that it is not so sensitive and that a positive reaction points strongly to an active rather than a latent process, especially so when supported by other indications.

Of the 361 children under discussion, 100 gave a positive and 93 a negative von Pirquet reaction. This does not represent the total number given the test, as many more received it but did not return to the dispensary to see whether the reaction was positive or negative.

The question naturally arises, What is the practical value of the von Pirquet or Morro test in determining the children who have true tuberculosis and those who can be disregarded? We are forced to conclude that they are of little value except as an evidence of hypersensitiveness. We have repeatedly seen anemic, under-

[5] Tuberculin in Diagnosis and Treatment, 1912.

nourished children with or without tuberculous parents who gave no reaction; and, on the other hand, we have encountered children who presented no physical signs who were in robust health and who had violent skin reactions.

SOCIOLOGICAL CONDITIONS. The really important thing to determine in regard to these children is this: Are they physiologically normal, and if they show any evidence of being below par, what is the cause? In the great majority of instances it will be found that those below the normal are suffering from sociological evils rather than tuberculosis. Viewed in this light it is relatively unimportant whether the child shows evidences of hypersensitiveness or not, because if allowed to remain amid unsanitary surroundings it will quite likely become infected, or if infection has already occurred the chances of true clinical tuberculosis developing are greatly enhanced.

It has been recognized for some years that the tuberculosis problem is a complex one and one that is not to be solved by purely medical procedures, so that in determining the question as to whether a child is in need of preventive treatment we are in the majority of cases confronted with a condition of malnutrition, partly the result of poor and insufficient food and partly the result of unsanitary living conditions. In other words, we have not discharged our duty to the child by simply saying that he has or has not tuberculosis.

Thus the general appearance of 141 of the 362 children was noted as being bad, while of 155 whose weight was recorded, 82, or 52.9 per cent., were found to be under weight for their age.

The term "pretuberculous" has been applied to that large group of children who, while not clinically tuberculous, are objects of suspicion, either because of tuberculous parentage, poor living conditions, or who are themselves badly undernourished. The term "pretuberculous" has been objected to, but as it has come to be so generally understood that it means children who, if allowed to drift, are prone to become actively tuberculous, that we can see no great reason for not using it.

Certain interesting facts are revealed as to the social conditions of the 362 children forming the basis of this paper, and while none of the facts are new, they will bear repeated emphasis.

These 362 children belonged to 210 families. What constitutes a proper income for a family of three or five or seven is somewhat conjectural, depending as it so often does on habits of thrift or extravagance. It is usually assumed, however, that not more than one-quarter of the income should be expended for rent, and that the food allowance should be $1.50 per week per capita, approximating 21 cents per capita each day. Of 154 families studied on this basis the number with an adequate income was 68, or 44.17

per cent., while 86, or 55.83 per cent., had an inadequate income; 50 families were paying an excessive rent.

The following table shows the extent to which over-crowding exists:

Families living in 1 room to each member	102
" " 1 " 2 members	70
" " 1 " 3 "	25
" " 1 " 4 "	8
" " 1 " 5 "	2
" " 1 " 6 "	2
" " 1 " 7 "	1
Total	210

Distinct overcrowding occurred in 38, or 18 per cent., of the 210 families.

Still another aspect of the problem is seen in the following table, which shows the number of rooms occupied by each family:

Families living in 1 room	17
" " 2 rooms	39
" " 3 "	52
" " 4 "	42
" " 5 "	20
" " 6 "	29
" " 7 "	4
" " 8 "	4
" " 11 "	1
" " 13 "	1
" " 14 "	1
Total	210

No data is available as to the hygienic conditions of these families at the time of the original examination, but we do know the conditions under which 111 of the children are at present living. A recent investigation shows that 48, or 46.2 per cent., of the children are living in poor, dirty, and unhygienic surroundings, while 13, or 11.7 per cent., of the home conditions are classed as only fair. The remaining 50 are living in clean surroundings.

Two facts are now well known: (1) that both the morbidity and mortality rates are always higher among those living under unsanitary conditions; and (2) that there is almost instant improvement in children when they are given sufficient nourishing food and healthful surroundings. The latter fact is now well established by reason of the results obtained in open-air schools and in sanatoria which admit children of the so-called pretuberculous type.

We would, therefore, repeat that the main problem consists in determining whether the child is physiologically normal, and if not, of using every endeavor to provide the means of making it so.

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THE POTTERY INDUSTRY AND ITS RELATION TO TUBERCULOSIS.

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That there is a growing interest in regard to the effect which occupation may have on the health of the working men and women of this country is evidenced by the numerous laws relating to industrial hygiene, which are being introduced yearly in the various state legislatures. If, however, we except the successful crusades which have been waged against lead and phosphorus poisoning, most of the remedial legislation has been directed towards the minimizing of accidents and very little has been done towards correcting evils which have a remote rather than an immediate evil effect on the health of the worker.

Within the past year or so, twenty-one potters employed in the several manufacturing establishments at Trenton, New Jersey, have been sent to the White Haven Sanatorium by the Local Union of the National Brotherhood of Operative Potters. My interest in the occupation was aroused, partly because a number of these men were assigned to my service and partly because of the fact that, as a group, the manifestations of their disease differed somewhat from those encountered in other patients who had much less involvement of the lungs.

Etiology. The manufacture of pottery in the United States is largely centralized in two places, namely, Trenton, N. J., at which place the manufacture of sanitary ware is the chief product, and East Liverpool, Ohio, where the major part of the output is confined to white ware. These two cities represented 41 per cent. of the total value of pottery products for the United States in 1909.

The total number of people employed in the pottery industry of this country is about sixteen thousand, and approximately five thousand of this number live in Trenton, New Jersey. (Mortality Statistics, Tenth Annual Report, Census, 1909.)

The term "potter" is a very comprehensive one, and is ordinarily understood to mean any workman employed in a pottery. It is to be borne in mind, however, that the occupation is one "having many departments between several of which no common characteristics can be said to exist. This holds true of the two principal departments, viz., (1) the making of articles from potter's clay, and (2) their ornamentation by painting and gilding." (Arlidge, Hygiene and Diseases of Occupation, 1892.)

A brief description of the process of the manufacture of earthenware is essential to a correct understanding of the risks to which the working men are exposed.

The initial process consists in mixing the clay with ground flint and water. This is very dusty work but requires only a few men. Formerly the mixing was done by hand; at the present time machinery is almost universally employed. After the mixing process is completed the resulting product, known as "slip" is passed through sieves, at high pressure, in order to expel as much of the water as possible.

The wet clay is then ready to be shaped into various articles, such as plates, cups, pitchers, etc., and sanitary ware. The men employed in the fashioning of articles by hand are known as pressers. Those making flat articles, such as plates, are known as jigger-men. The pressers are more skilled as they fashion the hollow ware such as cups, pitchers, etc., by hand, while the jigger-men make plates and other flat ware by machine. Both are exposed to the dust which arises from the lumps of wet clay which fall about them and eventually become dried out and pulverized. Most of the sanitary ware is made from molds composed of plaster of Paris; the dust from the latter being added to the clay dust.

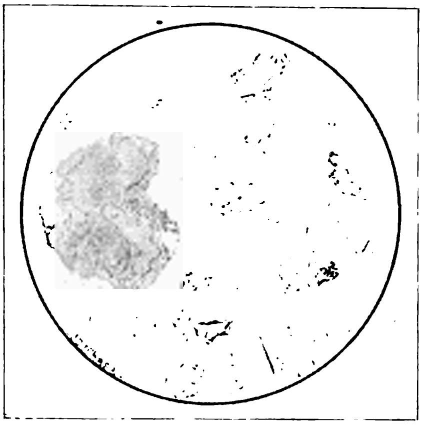

Fig. 1. Dust which is produced in "towing" or smoothing the ware. It is the same kind of dust that is produced from pulverizing the dried raw material, only finer. A small amount of flint enters into the composition.

After the various articles have been made from the wet clay they are set aside to dry out. The surfaces of the articles when dry are always more or less rough and uneven to the touch, and this roughness is removed by placing the hollow ware on a lath and the flat objects on a rapidly revolving disk, and rubbing them with tow or flannel. This completes the work of the pressers and jigger-men, and is known as "towing." The dust which is produced in this process is shown in Figure 1. After the required smoothness is obtained the ware is ready for the kiln.

The first firing is known as "biscuiting." The ware to be fired is placed in large thick-walled vessels, much the shape of a large cheese, and made of coarse clay. These vessels are known as "saggers." Into these the ware to be fired is placed, the different pieces being separated from each other and packed about with ground flint dust. This dust is pure white, very gritty to the feel and when inhaled is very irritating. A drawing of pure flint dust is shown in Figure 2. Because of its irritating qualities, manufacturers have tried, at different times, various substitutes. Nothing, however, has as yet been discovered which can replace the flint for the reason that all the materials tried contain impurities. These impurities, by reason of the high temperature to which the ware is subjected in the kiln (1800 to 2000° F.), are driven into the ware and thus ruin it because the stains cannot be removed or concealed.

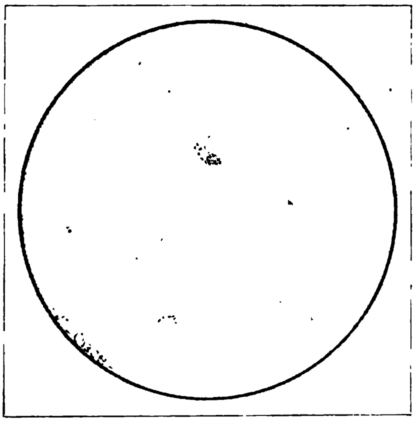

Fig. 2. Flint dust after being fired in the kiln with the ware. The kilnmen and girls cleaning the ware in the china potteries are exposed to it.

After the ware to be fired is placed in the "saggers," the latter are placed in the kiln and are built up tier upon tier until the kiln is filled. In addition to exposure to the flint dust the men who handle the "saggers" are exposed to alternating heat and cold from passing from the outside to the interior of the ovens, if recently heated. In addition there may be some sulphur fumes.

In the absence of precautions a tremendous amount of dust is present in the air of the work rooms. Lemaistre (quoted by Oliver in Dangerous Trades) from an analysis of the air in the Limoges potteries found the air in some of the workshops to be composed of earthy particles, fragments of granite, flint, particles of dried glaze, soot and wood charcoal. The atmosphere in which the porcelain makers generally worked was found to contain six hundred and forty million particles of dust to the cubic meter.

After the first firing or biscuiting, the ware is ready to be glazed and, in the case of articles which are ornamented, to be painted or imprinted by colored transfers. The ware is then ready for a second firing which is carried out as in the first instance.

The final process consists in chipping off the uneven projections on the under side of the plates, cups, etc. The ware is then sorted and is ready to be packed in barrels as required for shipment.

While the question of lead poisoning does not belong properly to the subject matter of this paper, some mention of it is necessary for a complete understanding of the subject. After the first firing, the fired clay or biscuited ware is dipped into a liquid mixture containing lead (15 per cent.). This process is known as glazing and the men who perform the work are called "dippers." In carrying out this process the worker has both hands and forearms immersed in the liquid almost constantly throughout the working day.

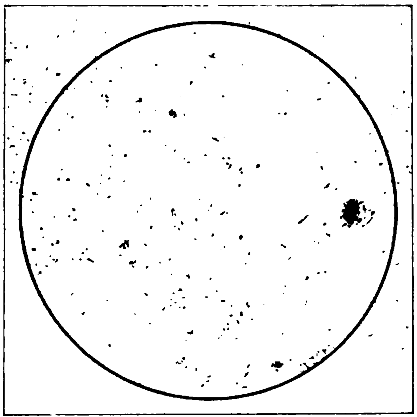

Fig. 3. Dust which contains a little lead. The dippers and kilnmen are exposed to it.

After the ware has been dipped in the glazing fluid it is set aside in a drying room until it dries, usually a matter of twenty-four hours. During this time a certain amount of the liquid drips off and rapidly dries.

For many years it was thought that the dippers were poisoned by the lead because of having their hands and arms immersed in the glazing fluid. It is now known that there is no absorption through the skin, but that the real danger lies in the swallowing of dust containing lead. (See Figure 3.) So long as the glazing material is in a liquid state or the dried material is not broken up into fine dust, there seems to be no danger, if in addition the workman is cleanly about his person.

Although lead poisoning is still unduly prevalent among the English potters it seems to have been eliminated entirely among the American workmen. This has been accomplished by the simplest of precautions. Not only is the dipper cleanly as to his personal habits, but in addition two rooms are used for the freshly glazed ware which is being dried. Before a room which has contained the freshly glazed ware is used a second time it is flushed out with a hose, and furthermore no one is allowed to walk about in the room and break up the dried glazing material on the floor.

Several of the dippers to whom I talked had been employed in this branch of the work over twenty years, without any ill effects. From them I learned that in former years it was the belief among the workmen exposed to the danger of lead that poisoning could be prevented if they got sufficiently drunk every Saturday night to bring on vomiting. This they thought eliminated any lead that might have accumulated during the week.

The following table shows the different departments in which the twenty-one workers were employed.:

Presser	8
Dishmaker ("jigger-man")	4
Kilnman	3
Dipper	1
Foreman (formerly mouldmaker)	1
Laborer	2
Unknown	2
Total	21

In addition to the working environment other etiological factors undoubtedly play a part in producing ill health among these workers. In former times, bad hygienic conditions prevalent among the English potters unquestionably had a strong determining influence in the production of disease. The marked reduction in both the mortality and morbidity rates among English potters is probably due in part to improved living conditions. Arlidge (Paper presented at the Social Congress, Leeds, Oct., 1871), the leading authority on the diseases met with in potters, in a paper contributed nearly fifty years ago, ascribed much of the high incidence of respiratory diseases among the potters of North Staffordshire, England, to the damp climate, unhealthy shops and habitations, defective sewage disposal and drainage, improper diet and vicious habits.

G. Calvert Holland (Diseases of the Lungs from Mechanical Causes), in a monograph on the respiratory diseases encountered among the employees of the various cutlery establishments at Sheffield, England, also emphasizes the influence of poverty, drinking and poor sanitation. In his opinion there is a distinct relation between intelligence and the duration of life. In other words, the workman with intelligence enough to protect himself during the actual conduct of his work and who, in addition, will observe the ordinary rules of hygienic living at home will counteract the risks of his employment much better than the careless or ignorant workman.

In this connection I might mention that in a recent visit to the Trenton potteries I saw several men who had contracted tuberculosis from two to three years ago. After their return from the sanatorium, with their disease arrested, they had returned to the pottery and had continued well. This could probably be ascribed to two causes, first, they took the best of care of themselves outside of working hours, and, secondly, they were extremely clean in the performance of their work.

While I have no personal knowledge of the home hygiene of the workers I had under observation, it is somewhat significant that eight of the twenty-one admitted the excessive use of alcohol.

The relationship which exists between wages and ill health is one of the burning questions of the day, and there are not a few who believe that an adequate wage will eliminate much of the ill health associated with many industries. In regard to this industry, however, such is not the case. The employees most exposed to the dust are, as a rule, skilled workers who command a good wage. Of the twenty-one men included in this report, seventeen were skilled workers capable of making from twenty-five to forty dollars per week prior to the onset of ill health.

The secretary of the Potters' Union at Trenton informed me that, so far as could be judged from reports from other unions throughout the country, there existed at the présent time, among the sixteen thousand potters, from one hundred and fifteen to one hundred and twenty cases of tuberculosis.

Pathology. The pathological changes induced by dust of various kinds depends to some extent on the intensity of the irritation set up. Exposure to almost any kind of dust even for a short time is apt to irritate the respiratory tract and produce coughing. This may become a true bronchitis if the exposure is sufficiently long. Between simple irritation as the result of a brief exposure, and extensive tissue changes, as the result of prolonged exposure, varying degrees of pathological alteration may occur.

Clay and flint both contain very hard, sharp, angular particles of silex, which when drawn into the respiratory tract during inhalation are not dissolved by the bronchial secretions, but are deposited in the alveoli and smaller bronchi. For a varying length of time the inhaled dust is arrested in its advance partly by the mucous secretion in the bronchial tubes and partly by the ciliated epithelium lining the tubes. Sooner or later, however, these defensive forces weaken, and finally the dust passes into the lymph channels, and also along the finer bronchi, until it reaches the parenchyma of the lungs. As a foreign substance it then sets up a chronic inflammatory process.

The histological changes which occur in the lungs from prolonged exposure to coal dust have been studied by Wainwright and Nichols (American Journal of Medical Sciences, 1905, Vol. CXXX). Inasmuch as the prolonged inhalation of any form of inorganic dust tends towards the same end, namely, the production of pulmonary fibrosis, the changes described by these authors, as occurring in anthracosis, are applicable to other forms of dust.

Wainwright and Nichols describe the changes which the deposit of coal dust produces as follows:

1. In the case of those who have worked in the coal mines but a few months some of the epithelial cells lining the alveolae become swollen and contain particles of coal dust. Sometimes a few larger desquamated cells containing much pigment are found in the alveolae lying loose with some detritus and free dust particles. Even in this early stage, dust particles are seen in the walls of the air vesicles and around the small bronchi. In this first stage there is no evidence of connective tissue proliferation.

2. In those who have worked in the mines for several years the swollen epithelial cells containing dust particles are much more numerous. The alveolae also contain more detritus consisting of swollen, dust-bearing epithelial cells, free dust and some leukocytes. At this time evidences of connective tissue proliferation become apparent. The pigment in the walls of the air vesicles becomes more marked and collects particularly in the connective tissue septa between the lobules where it is in such large masses as to be easily seen by the naked eye in the microscopic sections. These masses are especially well seen in the septa that run in from the pleura. In places considerable-sized black triangles are seen with their bases on the pleura, showing where some septum has been completely filled up with dust. With this deposit there occurs an increase in the connective tissue of the alveolar septa. The interlobular septa thicken as does also the peribronchial connective tissue, as here also the dust tends to collect. (The gradual evolution of the process is apparent from a study of a potter's lung made by Wilson Fox (Diseases of the Lungs and Pleura, 1891, p. 494). In the specimen described by him there were numerous round granulations varying in size from a pea to a millet seed, almost entirely composed of deeply pigmented fibrous tissue. Some of the older granulations were entirely converted into fibrous tissue having a concentric arrangement, but solid in the center, the pigment being also more or less concentrically arranged. In others, apparently more recent, there was a central part strongly resembling a bronchiole surrounded by a concentrically arranged fibrous tissue, between which and possibly contained in fusiform cells there was abundant black pigment in a finely gran-

ular form. The tendency of the dust to collect in masses at individual points is especially noticeable in the lungs of porcelain makers. According to Oliver (Dangerous Trades) small chalk-like masses are often found in the lungs, and to the uninitiated may be confounded with cretaceous tubercles.)

In this second stage the bronchial and mediastinal lymph nodes become enlarged. As a result of exposure to nearly any dust the bronchial lymph nodes are black and in the case of coal miners, intensely so. The nodes in the lesser omentum are also frequently pigmented from dust swollen in the saliva.

The connective tissue changes in this stage are almost never sufficient to give signs of consolidation.

3. It has long been recognized that the progress of the respiratory disorders incident to the inhalation of irritant dust may be arrested if the individual will seek some other employment. The reason for this is apparent from the observations of Wainwright and Nichols. They found that in the case of individuals who had formerly been miners, but who for many years had not followed that occupation, the lungs no longer showed signs of irritation. The swollen epithelium had subsided and again become normal, and neither the cells nor the alveoli contained dust. The deposits of dust in the alveolar walls, the septa and the peribronchial tissue, however, still remained as did also the connective tissue thickening.

The gross changes are briefly as follows: The first change noted is in the upper respiratory tract and occurs in the form of a pharyngitis which commonly persists, ten of the twenty-one cases reported in this paper had congestion of the pharyngeal mucosa. At this stage there may be some cough of a dry, hacking character. This is often the result of a tracheitis. Gradually the process extends downwards producing a bronchitis which sooner or later becomes chronic in nature. At this stage the lung begins to show the evidence of fibroid changes. Furthermore, as the result of the chronic bronchitis, varying degrees of emphysema develop, and we have the condition commonly known as miner's or potter's asthma.

As the fibrosis increases there is added to the picture dilatation of the bronchi. The dilatation of the bronchi is rarely sacular, but as a rule cylindrical and the bronchi are pretty generally involved. The dilatation of the bronchi results partly as the result of the loss of elasticity in the bronchial wall and partly as the result of the chronic inflammatory condition of the bronchial mucosa which tends to weaken the wall. The bronchi having lost their elasticity and, in addition, being weakened, are, therefore, apt to dilate to a greater or lesser extent from the strain put upon them by the cough.

The fibroid changes which occur as the result of dust are bilateral and fairly evenly distributed throughout both lungs. Partly because of this, and partly because of the associated emphysema, the marked chest deformity which characterizes unilateral massive fibrosis does not occur.

According to Oliver the dust is apt to first attack the posterior and inferior portions of the lungs rather than the apices.

The relationship which exists between the inhalation of dust and tuberculosis is an interesting one, and the belief that dust has a strong predisposing effect in producing pulmonary tuberculosis is pretty generally accepted. Mortality returns for years have shown that the death-rate among potters is excessive from respiratory disorders, particularly tuberculosis. Hoffman (Bulletin of the Bureau of Labor, No. 79, Nov. 1908) states that the experience of the Prudential Insurance Company for the years 1897 to 1906 shows that out of three hundred and eighty-four deaths among potters one hundred and twenty-seven or 33.1 per cent. were from tuberculosis, and that the rate was excessive from all ages. In addition there were fifty-seven deaths from respiratory disorders, other than consumption.

The Tenth Annual Report of the United States Census records one hundred and thirty-six deaths among potters of which forty-seven were due to pulmonary tuberculosis, a percentage of 28.9. In Trenton, New Jersey, for the year 1911 there were fifty-eight deaths among potters, from all causes, and of this number twenty or 34.4 per cent. were due to pulmonary tuberculosis.

At first sight these figures seem to point conclusively to the fact that the death-rate from tuberculosis is excessive among potters. When we recall, however, the changes which are produced in the lung by reason of the inhalation of inorganic dust, it is evident that the process is in the beginning of a non-tuberculous fibrosis of the lungs. Furthermore, it is well-known that the symptoms and physical signs produced by such changes are essentially the same as in tuberculosis. It seems quite likely, therefore, that in not a few instances it has been assumed that the process was tuberculous, and death was ascribed to this cause, without an examination of the sputum having been made to determine the true nature of the disorder. Tatham (Oliver's Dangerous Trades) in commenting on this aspect of the question states that: "Potters succumb to non-tubercular disease of the lungs much more rapidly than they do to tubercular phthisis, and it is certain that much of the so-called potter's phthisis ought properly to be termed cirrhosis of the lung. Deaths from this affection should never be included under the head of phthisis, which term is now restricted by universal consent to the tubercular malady of that name." One of the patients whom I had under observation was of this type. He had extensive pulmonary damage and all the symptoms of tuberculosis, and yet a number of sputum examinations were negative.

On the other hand it is to be borne in mind that the cause of death in cases of this type is not infrequently given as being due to chronic bronchitis, emphysema, pleurisy, etc. This might possibly equalize the error.

There is still another factor to be considered, namely, the effect of an antecedent fibrosis of the lungs. It is well known that the stimulation of connective tissue growth is the way in which nature overcomes tuberculosis. Therefore anything which stimulates such a growth in the lungs should aid in preventing the tubercle bacilli from getting a foot-hold, or in overcoming or retarding their growth, if they become established in the pulmonary tissue. This is the view held by Wainwright and Nichols, who found that true tuberculosis was not a frequent finding among coal miners, but that extensive fibroid changes in the lungs, as the result of coal dust, was exceedingly common. The protecting influence, in their opinion, was the fibroid tissue and not the coal dust itself, the latter having been held by some to have germicidal qualities.

While potters are not freed from the danger of becoming tuberculous by reason of the fibrosis which is produced incidental to the inhalation of clay and flint dust, it seems reasonably certain that the fibrosis does tend to retard the progress of the tuberculous infection. Thus it has long been recognized that the age period at which potters succumb to the disease is far beyond the average, and in addition, so far as my observation goes, the disease seems to be much less severe than the same amount of damage produced in other classes of patients.

Most of the available statistics on the subject support this view. Thus the English mortality statistics for the three years ending 1902 (Supplement to the Sixty-fifth Annual Report of the Registrar-General) states that the mortality of potters, between the ages of twenty to thirty-five years, falls below that of occupied and retired males generally. At every other age period, however, it shows an excess which amounts to no less than 74 per cent. at ages forty-five to fifty-five years, and to 66 per cent. at ages fifty-five to sixty-five years. The principal excess falls under the head of respiratory diseases. The following tables serve to indicate this point:

I. Proportionate mortality from consumption among potters, 1897 to 1906, compared with that of all males in the registration area of the United States, 1900 to 1906, by age groups. (Experience of Prudential Insurance Company, Hoffman, Bulletin of the Bureau of Labor, No. 79, Nov. 1908.)

Age at death.	Death of potters, 1897 to 1906, due to		Per cent. of deaths due to tuberculosis among males in registration Potters area, 1900–1906.	
	All causes.	Tubercu.		
15 to 24 yrs.	46	11	23.9	27.8
25 to 34 "	68	36	52.9	31.3
35 to 44 "	84	37	44.0	23.6
45 to 54 "	78	22	28.2	15.0
55 to 64 "	72	14	19.4	8.1
65 yrs. or over	36	7	19.4	2.7
Total	384	127	33.1	

II. From the Annual Report of the New Jersey State Board of Health for the year 1911:

Age.	Number of deaths from tuberculosis.
15 to 20 yrs	1
20 to 30 "	5
30 to 40 "	4
40 to 50 "	4
50 to 60 "	4
60 to 70 "	2
Total	20

III. Ages of patients included in present report:

15 to 19 yrs	1
20 to 24 "	1
25 to 29 "	5
30 to 34 "	1
35 to 39 "	4
40 to 44 "	5
45 to 49 "	1
50 to 54 "	3
Total	21

If we consider the length of time the men have been employed in the trade, it is evident that the tuberculous infection is engrafted on the fibroid process very late, or, in view of what has already been pointed out, that the tuberculous process, if an early manifestation, has been kept in abeyance. The tuberculosis finally gains the upper hand, because the general resistance has been reduced by the primary trouble plus certain habits of the individual to which we have previously alluded, namely, poor sanitation and dissipation.

The following table indicates the length of time the twenty-one cases I have had under observation worked in the trade:

Under 10 years.	10–19.	20–29.	30–39.	over 40 years.
2	8	6	3	2

From this it is seen that only two worked at the trade for less than ten years. The length of time the men worked in the pottery ranged from two to forty-two years, and the average for the twenty-one was twenty-one and seven-tenths years.

Symptoms and physical signs. Pulmonary disease as the result of inhaling irritating dust may manifest itself in three forms: (1) as ordinary tuberculosis, either acute or chronic; (2) as a general fibrosis of the lungs; and (3) a mixed form in which a tuberculous process is engrafted sooner or later upon the fibroid condition.

When tuberculosis occurs in a potter who has but recently entered the trade, or who, at least, has not followed the trade for a time sufficiently long to produce fibrosis of the lungs, the symptoms and course of the disease differ in no particular from those encountered under ordinary circumstances.

Fibrosis of the lungs is sometimes referred to either as fibroid phthisis, or, when the cause of the fibrosis is due to dust, as pneumoconiosis; the latter term, which is general, may be modified still further by indicating the character of the dust as chalicosis when due to flint dust, anthrocasis when due to coal dust, etc. Among the working men themselves such names as miner's asthma, grinder's rot, potter's rot or potter's asthma, are prevalent.

Fibrosis of the lungs is always slow in developing. As has already been indicated in the pathology of the process, it is a chronic inflammatory reaction taking place around many minute foci of dust, and which, as time goes on, tend to coalesce and involve larger and larger areas of pulmonary tissue.

In the beginning little or no inconvenience is experienced from the inhalations of dust. The first thing to be noticed is a slight irritation in, and a desire to clear the throat. Next a slight cough develops which may occur in the morning only. Later some blackish viscid mucus appears after the cough. As the process advances the cough and expectoration become more and more marked. Examination of the lungs at this stage will show the evidences of chronic bronchitis, and some emphysema. Physical signs indicative of consolidation are rarely met with at this time, although they may occur.

At some period, rarely less than ten years, and not infrequently more than twenty of continuous employment, the worker begins to experience some tightness in the chest, the breathing gets shorter and shorter and finally the disturbed lung function becomes so pronounced as to render the victim less and less capable of exertion. In spite of this condition, however, the general health may be but little impaired, and unless the dyspnea be too great, the patient may not be compelled to cease work.

By this time the fibroid changes in the lungs have become extensive, although the physical signs may indicate nothing more than a diffuse chronic bronchitis. There is quite likely to be added to the picture, however, evidences of bronchiectasis. Cavity signs may be present, commonly in the region of the angle of the scapula, and when they are, a diagnosis of tuberculosis is usually made. Marked clubbing of the fingers and the expectoration of large quantities of sputum, sometimes of a foul odor, are also strongly suggestive of bronchiectasis.

The distinguishing feature of general fibrosis of the lungs is the contrast between the extensive pulmonary lesions and the absence of marked constitutional symptoms. "Herein fibroid phthisis presents a well marked difference from pulmonary tuberculosis; and even if, as we have said, the disease becomes complicated with tubercle, yet the rate of progress may be determined rather by the character of the primary than of the secondary disease, though usually the supervention of tubercle hastens the sufferer into a more rapid consumption." (Report of British Departmental Committee on Compensation for Industrial Diseases, 1906, p. 13.)

With one exception, the cases I have observed belonged to the class in which tuberculosis was apparently engrafted upon a fibroid process. The initial symptoms in these patients were apparently trivial, and the duration of their disease, as given by the patients themselves, was as follows:

Under 1 year	9
1 to 2 years	9
4 to 5 years	3
Total	21

Contrasted with the length of time they were ill, it is interesting to note the stage of the disease as judged from the signs indicative of pulmonary damage:

Incipient	1
Moderately advanced	3
Advanced	16
Non-tuberculous	1
Total	21

During the time they were under observation (from two weeks to six months and longer) fever was absent in four; in fourteen the temperature did not exceed 100° F.; and in three temperature range was above 100°F.

Tubercle bacilli were found in fifteen; in five the sputum was negative, but only one of these had repeated examinations. The remaining four had but a single specimen examined, and for this reason one cannot be certain that they were not actually tuberculous. One case had no sputum.

Dyspnea was pronounced in fourteen of the twenty-one.

Loss of weight had occurred in all but one.

Marked clubbing of the fingers and curving of the nails were noted in ten of the twenty-one.

Finally, it is to be noted that with two or three exceptions, these patients did not impress one as being very ill, even those who had slight persistent fever every afternoon.

Prevention. As has already been stated, the improvements which have been made in the process of pottery manufacture have led to a reduction in both the morbidity and mortality rates of those following this occupation. This is especially true in regard to lead poisoning, which had practically disappeared among American potters.

The dust problem, however, has not as yet been completely solved. The dust which is most feared by the potters themselves is the flint dust used in packing the clay ware for firing, and entering, to a slight extent, into the composition of the raw material. The danger from this source could be greatly minimized if the "saggers" were packed and unpacked under exhaust hoods, which would remove the dust that is stirred up in this process. In addition there should be devised some better method of delivering the flint dust from the storehouse. As it is the dust is carried by the workmen in uncovered boxes and small amounts are apt to be spilled in transit.

"Towing," or the removal of the rough surfaces from the dried clay ware, could also be rendered safer if the work were performed under an exhaust hood. Oliver states that the dust difficulty in this process "can to a large extent be got over by finishing the ware in the 'green' condition." In some of the French potteries the slightly moist ware is smoothed with paper before being heated.

The most difficult problem is to prevent the accumulation of the dust which comes from the small fragments of wet clay thrown off in the process of fashioning the various articles. At the present time the major portion is removed by sweeping out the rooms after work hours. Oliver contends that much can be done by means of improved ventilation, and that in addition to open windows, fans and strong aspirating draughts must be provided.

It is not to be forgotten that the workman himself has a very important part to play in the prevention of disease incident to this occupation. Not a little of the danger from the dust could be eliminated if the workmen made frequent changes of their working clothes. As a rule the men wear their working garb for an indefinite period, and as a result the meshes of their aprons and shirts become filled with the clay. The movements incident to their work are constantly releasing some of this fine, impervious dust and in this way much is inhaled which ordinary cleanliness would prevent. A covering for the head could also be used to advantage.

My own observations have led me to believe that more care could be exercised on the part of the workman in the disposal of the fragments of clay which are thrown off in the fashioning of the various utensils. Too much of it is allowed to fall on the floor about the work bench, and as a result is walked upon and quickly pulverized into dust.

Face masks have been repeatedly advocated, but have never been particularly successful for the reason that the workmen are averse to using them.

Because of the fact that the respiratory disorders of potters are extremely slow in their evolution, and because it is known that removal from the occupation will check the progress of the trouble, the individuals will follow this trade, especially those working in the dusty departments, should be subject to frequent medical inspections. A compulsory medical examination three or four times a year would undoubtedly result in detecting many cases which otherwise would pass into the terminal stages of potter's asthma or tuberculosis.

Finally, the life of the workman outside of his hours of employment plays a part which cannot be ignored in estimating the various factors which bring about ill health.

In this occupation as in many others, it is well to remember that in the badly ventilated state of one factory compared with another, the home life and surroundings of the work people, poverty, heredity, age and sex are to be found conditions that favor the production of ill health, and are therefore, not to be ignored. Usually it is a gradual deterioration of health that is produced. There is nothing of the nature of an acute illness in industrial disease comparable with an accident, except possibly anthrax.*

* Oliver's Dangerous Trades.

The Larynx in One Hundred Cases Dying of Pulmonary Tuberculosis

A Clinical Post-Mortem Study

By GEORGE FETTEROLF, M.D., Sc.D.

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THE LARYNX IN ONE HUNDRED CASES DYING OF PULMONARY TUBERCULOSIS.*

A Clinical Post-Mortem Study.

BY GEORGE FETTEROLF, M.D.

This paper is the outcome of an attempt to ascertain to what degree those dying from pulmonary tuberculosis suffer from tuberculous disease of the larynx. The material studied consisted of the larynges of one hundred patients who had died at the Henry Phipps Institute, and who had had autopsies performed on them by Drs. C. Y. White or P. A. Lewis, pathologists. In each case the larynx had been removed and examined at autopsy simply for the presence or absence of tuberculous disease. It had then been hardened in formalin and later transferred to alcohol. To have conducted this investigation on fresh material would have been better, but this was impossible, as the hour of holding the autopsies precluded the attendance of the writer.

The specimens were studied in the following way. The upper margin of the epiglottis and of the aryteno-epiglottic folds, and the upper surface of the arytenoid cartilages were first examined. Then the tongue was cut away flush with the anterior surface of the epiglottis to allow of careful study of the latter. Following this the hypopharynx and the esophagus were split posteriorly and turned aside, so as to expose the posterior surface of the arytenoids. Then the hyoid bone was divided with bone forceps, and the epiglottis and the thyroid and cricoid cartilages were split in the anterior median line. The larynx was then cautiously spread apart, so as not to tear the posterior commissure, and all hardened and adherent sputum was removed from the interior of the larynx and its ventricles. After a study of the laryngeal interior a posterior vertical cut was made between the arytenoid cartilages and through the signet part of the cricoid. Following this twelve pieces were cut out

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* From the Henry Phipps Institute of the University of Pennsylvania.

for microscopical study, the removed portions being one from each half of the epiglottis, both aryteno-epiglottic folds, both arytenoids, a section of each vocal cord, a section of each ventricular band, and a section from each half of the interarytenoid tissue. When gross lesions were present the segments were cut so as to include them.

The present report will deal only with the gross appearances, the microscope findings being left for a future communication.

Of the patients from whom the specimens were removed sixty-eight were males and thirty-two were females. This discrepancy is apparent only and is due to the fact that the Phipps Institute at that time had accommodations for twice as many male as female patients.

Of the one hundred cases eighty-three showed gross tuberculous lesions, thirteen showed absence of disease and four were doubtful. In other words, eighty-three per cent of these one hundred patients dying from pulmonary tuberculosis or its complications had definite gross tuberculous involvement of the larynx. The probability is that the percentage of those having actual disease is greater than eighty-three, for unquestionably some of those which appeared normal to the unaided eye will show tubercle formation under the microscope.

The Epiglottis.

This cartilage was involved in fifty-nine cases, was free of disease in thirty-seven and was of doubtful appearance in four. Here again the microscope will probably increase the number of cases in the positive list. This much, however, can be stated: Over half of the dying cases of pulmonary tuberculosis will present to the clinician infiltration or ulceration of the epiglottis. A practical corollary to this statement is that over half of the dying tuberculous will need relief for the pain they suffer in swallowing. Involvement of the epiglottis practically always causes odynophagia, and a sad feature is that there exists no adequate local method of giving relief, short of some surgical procedure. And the cases in which the latter can be used are few, on account of the small number of consumptives, taking the world over, to whom skilled laryngologic technique is available.

The form, location and multiplicity of the lesion varied greatly. Naturally the different forms are simply different stages or phases of the tuberculous invasion, and they are described more from the clinical than from the pathological point of view.

Infiltration.—This manifests itself clinically as thickening and, in life, congestion. Incidentally, pallor is rarely, if ever, seen in diseased parts of the tuberculous larynx. In an uninvaded larynx in a tuberculous patient, the mucosa may be pale, as part of a general cachectic pallor, but where the tuberculous process exists there will be found congestion contiguous to it.

Infiltration alone was found in twenty of the fifty-nine cases, and in each one of the twenty both halves of the epiglottis were involved. In only two of the twenty was the infiltration more marked on one side than on the other. This is as would be expected, for there is no part of the larynx, with possibly the exception of the interarytenoid space, which would be less affected by a more or less constant one-sided decubitus and consequent accumulation of bacillus-laden sputum, than would be the epiglottis.

In nine of the twenty the thickening was confined to the upper edge, and in five of these nine to the central part. In one case there was associated with the infiltration a large tuberculoma which covered the cushion and the area immediately below it. In another there was found marked edema of the supra-lingual portion of the epiglottis; a curious feature of this case was that the edema was confined absolutely to the anterior surface of the cartilage, the posterior surface being unaffected.

Infiltration with Superficial Ulceration.—This represents a later stage than mere infiltration, and was found almost as frequently, nineteen cases presenting this combination. Of these nineteen, eighteen involved both halves of the epiglottis, but a single case being limited to one side.

The ulcers varied in number, in five cases there being but one; in the others they varied from two up to a large number. No enumeration was made in those presenting a large number.

As regards location they showed a marked predilection for two sites, viz., the upper edge and the laryngeal surface. In but one instance were there any found on the lingual surface; in this specimen there were many erosions and they were widely distributed over the laryngeal and lingual surfaces, as well as on the free edge. Evidently the anterior facies is not as vulnerable as it looks. Comparing the appearance of the two surfaces, the laryngeal certainly *looks* tougher than the lingual. This, in combination with the thought that infective sputum would tend to gather in the glosso-epiglottic fossae, would *a priori* suggest the anterior surface as a likely spot for infection. Such is evidently not the case, however. Those parts of the cartilage which are most exposed to the air, food and sputum streams show the preponderance of infection. With these findings in mind one is tempted to conclude that the anterior facies of the epiglottis should be regarded clinically as a part of the mouth, and the posterior facies as a part of the larynx.

The single ulcers were located as follows: Four were on the upper edge and one, quite large and very shallow, was situated on the cushion near the median line. In one of these specimens one-half of the cartilage was almost completely denuded of epithelium and associated with it was a large tuberculoma on the laryngeal surface.

When the free margin is involved, both in infiltrative as well as in ulcerative lesions, the upper is much more frequently involved than are the lateral edges, probably on account of a poorer blood supply, but possibly, too, on account of its being more in line with the glottis and the exhaled sputum.

Infiltration and Deep Ulceration.—This combination was found in four cases. In one it consisted of a single ulcer on the free margin, with the cartilage protruding from the base as a knife-like edge; in the second there were numerous small ulcers on the laryngeal surface and extending into the cartilage; in the third there were ulcers on both surfaces, as was also the case in the fourth along with similar lesions of the free edge.

Infiltration with Superficial and Deep Ulceration.—Three cases fell into this group, and in all of them the general involvement was of the same plan, viz., thickening and shallow ulceration of the free portion, with deep ulcers in the neighborhood of the cushion.

Superficial Ulceration.—In this group are placed those cases which presented ulcers, with no infiltration except immediately around the ulcer. There were found ten of these, and in each one the involvement was bilateral; the ulcers were multiple in every instance. Of the two surfaces of the cartilage, but one, the laryngeal, was affected, and all of the ten cases were confined to this facies, with one exception, and in this the upper edge was involved. In one case the cushion was the only part affected.

Deep Ulceration.—This group is intended to include those cases in which there had been marked loss of tissue. Four cases answered the description; in two the whole upper edge of the epiglottis had sloughed away, in the third the entire left edge was gone, and in the fourth the cartilage was bare at the upper edge for the length of 1 cm.

Tuberculomata were found springing from the laryngeal aspect of the epiglottis in two instances. Both of them were sufficiently large to hide most if not all of the cords during life. They must have interfered to some extent with the respiratory act.

The Aryteno-Epiglottic Folds.

Fifty-eight cases showed positive gross evidence of tuberculosis of these structures, fifty-seven bilaterally and one unilaterally. As a rule, these folds do not become affected early in the disease, and it is therefore natural to expect the involvement to have become bilateral when the invasion has extended this far. This fold is rarely the primary site of the laryngeal disease, its infection usually being secondary to that either of the epiglottis or of the arytenoid, or more rarely of the ventricular band.

Infiltration only was found in forty-eight of the bilateral cases and in the single unilateral case. There was no great tendency shown toward the localization of the disease in any particular portion, although in a few instances certain parts showed a preponderance of disease. In eight the cartilages of

Wrisberg were the most notably hypertrophied, while in two the infiltration was confined to the arytenoid end of the fold. In six the amount of swelling was greater on one side than on the other. Distinct submucous tubercles were visible in three, in one instance being confined to the mesial surface, and in another to the same surface and to the superior margin.

Edema in conjunction with infiltration was found in a surprising number of instances. This condition was assumed to be present when the mucosa was found to be markedly shriveled, and was noted in twenty-two of the forty-nine infiltrated cases. This is probably explained by the loose histological texture of the fold, and this structural condition probably is the reason why so few of the tuberculous lesions found here are ulcerative. The looseness of the tissue allows of ready infiltration, and clinically it is sometimes quite astonishing to see with what rapidity a tuberculous process will advance along this fold from a red and swollen arytenoid, or from an epiglottis in the same condition. Again, the comparative infrequency of ulcers may be due to the fact that large areas of submucous tissue may be extensively infiltrated or caseous before the pressure becomes sufficiently great to cut off the surface blood supply and cause necrosis of the mucosa.

Infiltration with Superficial Ulceration occurred in seven cases, in four of these the disease being of similar degree on both sides; in the other three the infiltration was on both sides, but the ulcerative process was on only one. In one of the former the process was so extensive that the fold was practically denuded of epithelium. In another there were submucous tubercles on both sides, but on only one had these become confluent and opened on the surface. In a third the ulcers were noted as appearing on the internal surface only.

Infiltration with Superficial and Deep Ulceration was found in but one instance. In this specimen the disease was very extensive, there being no portion of the larynx unaffected by the tuberculous process.

Deep Ulceration alone was found once. This was in a specimen in which the disease was very general and far advanced.

Deep ragged ulcers were found on both surfaces of the epiglottis, on one ventricular band and on both arytenoids. Thus surrounded there is every reason why the folds should have been so extensively diseased.

Associated Disease.—Of the fifty-seven bilateral cases, forty-four were associated with tuberculosis of both arytenoids and forty-two with similar disease of both halves of the epiglottis. Two presented concomitant disease of both arytenoids, but of only one-half of the epiglottis. Five of the fifty-seven bilateral cases had associated involvement of the arytenoids only, and one of the epiglottis only. In three of the bilateral cases the fold presented evidence of disease independent of both the epiglottis and the arytenoids. Of these three specimens, two showed no signs of disease anywhere else in the larynx, while one had an associated involvement of one vocal cord.

The Ventricular Bands.

Forty-two cases showed undoubted tuberculosis of the ventricular bands and one was doubtful. Of the forty-two, thirty-eight were bilateral and four were unilateral. This is as would be expected, for these structures are not of those which are the most susceptible to tuberculous invasion, and therefore, they are usually involved in the later stages of the disease, where the tendency toward wide-spread involvement is more pronounced. They infrequently are involved alone. Occasionally, in the living, one will find a larynx in which a single vocal cord is hidden to a greater or less extent by an infiltrated and swollen ventricular band, but these cases do not occur with any great degree of frequency.

Of the thirty-eight bilateral cases, thirty-two presented similar lesions on the two sides. This is another point tending to show that isolated lesions of this part of the larynx are rare and that involvement of the bands is indicative of a general rather than a localized process. Additional evidence of this is furnished by the fact that in thirty-six of the thirty-eight practically the entire larynx was involved in the tuberculous process.

Infiltration.—Eighteen of the thirty-six, just half, were simply infiltrated, the evidence in general being a thickening of the band and a rounding of its free edge. In three the mucosa was quite shriveled, and a fair assumption is that this condition is a vestige of edema which had existed during life. In one the tissue of the band was peculiarly spongy in texture, a condition whose pathology must be left to microscopical examination for interpretation. In one the normal band tissue was entirely replaced by irregular nodular tissue. This same condition prevailed on the arytenoids and cords, and the epiglottis was the seat of a large tuberculoma. This larynx probably is a good specimen of the hyperplastic form of the disease, and should prove very interesting under the microscope. In another specimen the mucosa of one band was quite shaggy; possibly this is another case of hyperplasia similar to the one just described. Two specimens showed a preponderance of infiltration of one side over the other. This is a very small proportion and points still further to the probability that involvement of the bands occurs seldom except when the invasion is quite general.

Infiltration with Superficial Ulceration was found in three cases and was bilateral in all three. In one there was present infiltration alone on one side, and a superficial ulcer on the other, while in three others one band was infiltrated and the other was the seat of a deep ulcer. All three of these ulcers were just above the vocal process of the arytenoid and extended sufficiently deep to expose the cartilage.

Of the four unilateral cases, all presented simple infiltration only. One was associated with bilateral ulceration of the epiglottis and one with a similar condition of the vocal cord of the same side.

Superficial Ulceration.—This stage of the disease was found in seven of the thirty-eight bilateral cases. In two the ulcers were confined to the lower surface, and were really ulcers of the upper boundary of the ventricle. In one the band was practically denuded of mucous membrane and was studded with tubercles. Had this patient lived longer these tubercles probably would have become confluent and broken down, resulting in an extensive destruction of the laryngeal interior.

Deep Ulceration.—This is noted as having occurred in four of the thirty-eight bilateral cases. In two the bands shared in large ragged ulcers which were located on the anterior aspect of the arytenoids. In a third the bands were involved coincidently with the epiglottis in large, deep ulcers situated near the lower end of the latter.

In two cases one band was ulcerated superficially and the other deeply. In both of these the more advanced lesion was at the vocal process and in one was shared in by the vocal cord.

Associated Laryngeal Disease.—As bearing on the conclusion that involvement of the ventricular bands is likely to occur only late in the disease and as part of a generalized process it is interesting to note to what degree the other parts of the larynx were involved in cases which showed infection of the bands. The figures in this connection are as follows, and, like all the enumerations in this article, they probably would be altered slightly were the observations checked by microscopical study:

All the rest of the larynx	32
Epiglottis, aryteno-epiglottic folds and arytenoids	1
Epiglottis, aryteno-epiglottic folds and vocal cords	1
Epiglottis, arytenoids and vocal cords	1
Aryteno-epiglottic folds, arytenoids and vocal cords	1
	36

The Vocal Cords.

Either both or one of these structures were involved in forty-nine cases, both sides being affected in forty-two and one side in seven.

Infiltration alone was noted in ten cases, all of them bilateral. In one of these there was a large tuberculoma on the epiglottis, while the rest of the laryngeal interior was markedly nodular. The cords were very irregular and were dotted with tubercles on both their upper and mesial surfaces. In only one was the involvement more marked on one side than on the other, the remainder showing about the same amount of disturbance on the two sides. In one there was a marked roughness on only the free edge. In but one was there any edema.

The combination of later stages than infiltration with this condition was found to be more varied and protean than in any other part of the larynx.

Infiltration with Superficial Ulceration was found bilaterally in three instances, and in a fourth one side presented this combination, while the other was infiltrated only. Infiltration of one cord with superficial ulceration of the other was found once.

Infiltration with superficial ulceration of one cord without any involvement of the other was seen in two instances. In one there was a single shallow linear ulcer on the adductor margin and anterior to the vocal process, while in the other there were two such ulcers.

The combination of *infiltration with deep ulceration,* the condition being present on both sides, was found but once. This specimen was rather unique in that the greatest amount of involvement, and all of the necrosis was in the anterior part of the cords. This case is a reminder to the writer of another rare lesion seen in the living. Both cords in this instance were red and granular, and eventually they both ulcerated at their anterior halves. Subsequently to this the cords began to fuse, until finally they were joined absolutely into one broad, white sheet in their anterior half. Posteriorly there was left a small rounded glottis, which was adequate for respiration; the voice was a whisper only.

Infiltration with Deep Uulceration of one cord, the other being normal, was noted once. The ulcer was a large, ragged one and was located just in front of the vocal process of the arytenoid cartilage.

Infiltration of one cord with infiltration and deep ulceration of the other was noted in one instance, the ulcer being at that favorite site for such lesions, viz., the vocal process of the arytenoid. Infiltration of one cord with deep ulceration of the other was observed once.

Infiltration and superficial ulceration of one cord with infiltration and deep ulceration of the other was found twice. The shallow ulcers were found on the ventricular and infraglottic surfaces of the one cord, while the deep ones were located at the vocal process. In one of these cases a small pedunculated growth was found attached to the anterior part of one cord.

Superficial Ulceration was observed in eighteen specimens, bilaterally in fourteen and unilaterally in four. In four specimens the ulcer was of the nature of a shallow fissure. These usually started at the vocal process and extended forward on the adductor margin for a varying distance. In only one specimen were they on the superior surface of the cord. They were of the rounded form in ten cases and nine of these were situated at the vocal process. In the tenth the lesion of one side was small and located at the vocal process, while that of the other involved the posterior two-thirds of the approximating surface.

Deep Ulceration was present in four of the specimens, all bilateral and all situated anterior to the vocal process. In one the entire floor of the ulcer was studded with tubercles.

The Arytenoid Cartilages.

These structures were involved in fifty-seven of the one hundred cases. A rather curious feature is that all of them were bilateral, not a single specimen of the series showing disease of one cartilage alone. At the same time it should be stated that in a number of instances the involvement was greater on one side than on the other.

Infiltration only was present in forty-four of the series, and in two it was noted that the cartilages were of huge size. These were both of that clinical type, seen rather rarely, in which the larynx, especially the upper ring, composed of the epiglottis, the aryteno-epiglottic folds and the arytenoids, becomes tremendously infiltrated and remains so. These cases may cause little discomfort, and they may hang fire for months, or as seen by the writer in two instances, for years, the patient dying of tuberculosis but the larynx apparently being a very slight factor in his illness.

In one of the forty-four the arytenoids were very nodular and irregular, as was the entire larynx, and in another submucous tubercles were visible in the upper portion, not a common feature of tuberculosis of the arytenoids.

The infiltration was notably greater on one side in six of the specimens.

Edema of the infiltrated arytenoids was present in twelve of the forty-four. In one of these it was noted as being "tremendous," in a second as "marked," while in a third it was present on only the posterior surface. This condition of the last specimen must have caused serious mechanical interference with swallowing.

Infiltration with Superficial Ulceration occurred in eight cases. In seven the lesion was symmetrical, the eighth showing infiltration of both sides with ulceration of but one. In but one of these was the arytenoid of any very great size, this specimen showing infiltration to the size of a cherry. In three of the eight the ulceration extended beyond the laryngeal surface of the cartilage, two of them being involved on their pharyngeal and one on the superior surface. In one of the four the cartilages were practically denuded throughout of epithelium, a condition which must have been productive of hideous suffering.

Infiltration with Deep Ulceration was found in three cases, each differing from the other. One showed marked enlargement of the cartilages, with deep, ragged ulcers at both vocal processes. A second showed marked infiltration of both arytenoids, with a deep, narrow ulcer at the vocal process on one side only. In the third both were infiltrated, while one was the site of a small shallow ulcer and the other of a very deep one which bared clearly the vocal process.

Deep Ulceration only was noted twice, in one instance deep symmetrical ulcers being present at the vocal process, and in the other one being above this process and the other on the laryngeal aspect of the cartilage.

The Interarytenoid Space.

This area was found to be involved in forty-nine specimens, and in none of them were found conditions which endangered life. Usually the earliest signs of the disease are found here, and undoubtedly a much larger proportion than forty-nine per cent. would show microscopic evidence of disease. Here is frequently found the cause of the early hoarseness so often noticed, but this depends on the position of the lesion. If the latter is low down and between the vocal processes hoarseness is early evident, but, on the other hand, there may be quite large masses present in the upper part of the space without any notable vocal change. Indeed, it is quite disappointing to remove such masses from the posterior wall and then find no improvement, because a small amount of thickening inferiorly is the cause of the hoarseness.

Infiltration of varying degrees was present in forty-seven cases. In the vast majority this consisted of a small amount of thickening of the area. In three there were found quite large masses projecting forward between and above the vocal cords.

In two specimens was found a rather unique and entirely unexpected condition of affairs. Both presented the same surface appearance and in both was found precisely the same condition when the larynx was cut into for specimens. The space was somewhat elevated and when a knife was passed vertically between the arytenoids and down to the cricoid both above and anteriorly it was seen that the posterior commissure was the seat of a small spherical submucous abscess of about the size of a sturgeon's egg, as is found in caviare. While this form and location of lesion may have been described, the writer has no recollection of having met with it in the literature.

Superficial Ulceration was found four times. It probably was present more frequently, but this area was found to be the most difficult of all in which to diagnose lesions in the preserved specimen. As stated in the beginning, this study is one of gross conditions only, of conditions such as would meet the eye of the clinician and the figures presented must be accepted from that standpoint only.

General Summary.

Tuberculous	83
Non-tuberculous	13
Doubtful	4
Total	100

Epiglottis.

Tuberculous	59
Non-tuberculous	37
Doubtful	4
Total	100

Infiltration	20
Infiltration with superficial ulceration	19
Infiltration with deep ulceration	4
Superficial ulceration	10
Deep ulceration	4
Tuberculoma	2
Total	59

Aryteno-epiglottic Folds.

Tuberculous	58
Non-tuberculous	42
Doubtful	0
Total	100

Infiltration	27
Infiltration with edema	22
Infiltration with superficial ulceration	7
Infiltration with superficial and deep ulceration	1
Deep ulceration	1
Total	58

Ventricular Bands.

Tuberculous	42
Non-tuberculous	57
Doubtful	1
Total	100

Infiltration	18
Infiltration with superficial ulceration	11
Superficial ulceration	7
Deep ulceration	6
Total	42

Vocal Cords.

Tuberculous	49
Non-tuberculous	51
Total	100

Infiltration	10
Infiltration with superficial ulceration	7
Infiltration with deep ulceration	6
Superficial ulceration	18

Superficial and deep ulceration	4
Deep ulceration	4
Total	49

Arytenoid Cartilages.

Tuberculous	57
Non-tuberculous	43
Total	100

Infiltration	44
Infiltration with superficial ulceration	8
Infiltration with deep ulceration	3
Deep ulceration	2
Total	57

Interarytenoid Space.

Tuberculous	51
Non-tuberculous	49
Total	100

Infiltration	47
Superficial ulceration	2
Total	49

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UNIVERSITY OF PENNSYLVANIA

TENTH REPORT

OF THE

HENRY PHIPPS INSTITUTE

FOR THE STUDY, TREATMENT, AND PREVENTION OF TUBERCULOSIS

PULMONARY ACOUSTIC PHENOMENA

BY

C. M. MONTGOMERY, M.D.
OF THE HENRY PHIPPS INSTITUTE

AND

E. A. ECKHARDT, PH.D.
DEPARTMENT OF PHYSICS, UNIVERSITY OF PENNSYLVANIA

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PULMONARY ACOUSTIC PHENOMENA.

AN INVESTIGATION OF SOME OF THE FACTORS CONCERNED IN THE ORIGIN AND TRANSMISSION OF SOME OF THE SOUNDS HEARD OVER THE LUNGS IN HEALTH AND DISEASE.

INTRODUCTION.

While our clinical interpretation of the significance of many of the sounds audible over the lungs has long since reached a very satisfactory stage of development, it is cause for regret that even to-day noted authorities hold very divergent opinions as to the explanations for many of these sounds, and a number express dissatisfaction with all explanations offered on some important points. This very divergence of opinion is itself proof that at least some of the contradictory teaching must be faulty. It seemed worth while, therefore, even if we should make no further progress, to try to dispel some of this confusion, and at least to determine more definitely the extent and the limits of our knowledge of the mechanism of some of these auscultatory phenomena, for we felt that success even this far would render the task of advancement along these lines easier for others.

Although this whole subject may seem to have only theoretical interest, and not to possess any practical possibilities, or, while it may be true, as Austin Flint says, that it is not necessary to study the science of acoustics to determine the clinical importance of the sounds we hear, yet most of us like to know a little about the inner workings of the tools we have in daily use; and who can tell but that a deeper insight into the mechanism of the sounds heard over the chest may eventually lead to practical results, just as there are grounds for believing that the application of the science of acoustics to musical sounds may in time lead to still more beautiful music? More than a century before Laennec was using his stethoscope Robert Hooke, in an inspired passage, asked the question, "Who knows, I say, but that it may be possible to discover the motions of the internal parts of bodies, whether animal, vegetable, or mineral, by the sound they make?" And it is significant that those who have contributed most of what is valuable in regard to the clinical interpretation of the physical findings over the lungs, have, as a rule, been the ones who have exhibited the keenest interest in solving the mysteries of their mechanism.

It is true that a good many clinicians have delved a little into the subject of the mechanism of the auscultatory phenomena encountered over the surface of the lungs, but few give evidence of having attacked the subject in any really serious way. The brief list of works appended to this paper covers, we believe, a large part of the best efforts directed toward elucidating the elemental factors operative in producing the familiar pulmonary sounds.

It will not be possible, nor would it be profitable, in the limited space allotted to this paper, to enter in any detail into the various theories held by different laborers in this field of endeavor. Some of the more important hypotheses will naturally be presented. If the facts we have to offer and the conclusions drawn are correct, they will furnish the best defense or criticism we can furnish of the point of view of these different authors.

A study of the literature reveals three different ways which seem to have been responsible for most of the errors into which various authorities have fallen. The first of these has been the misunderstanding, or, perhaps, even more, the misapplication, of even the simplest laws of acoustics. For ignorance of some of these laws no one is to blame. Helmholtz's first edition of his *Lehre von den Tonempfindungen* did not appear until 1863. As late as 1885 K. von Vierordt states that Müncke's saying, written in 1838, still holds true, that the conductivity of solid bodies in particular "noch kaum mit nur irgend einer Genauigkeit untersucht worden ist." Acoustics seems always to have lagged behind the other branches of physics, such as heat, light, and electricity, and even to-day a regrettable silence hangs over many of the mysteries we should dearly like to see unravelled. Is it any wonder, then, that physicians, who, as a class, know very little about even the revealed laws of acoustics, should have occasioned the somewhat humorous remark, levelled at them by Niemeyer, "Die Unsicherheit, in welcher man bis auf den heutigen Tag schwebt, wird recht drastisch Widerspruch mit dem A B C der Akustik und mit einander selbst aufbieten, um die nun einmal durch den Gebrauch geheiligte Tradition zu retten"?

The acoustic laws to which we shall appeal in the following pages are, for the most part, most simple and intelligible, and their assistance will not, as far as we can avoid it, be invoked in advance to prove any point we might like to make, but will be referred to only in so far as they seem to apply to and to support any facts that may have been demonstrated by experiment. In other words, we have tried quite as much to represent, through imitation, what occurs in the body, as to explain why certain results are encountered.

The second, and often an inexcusable, mistake met with in the literature, furnishes additional evidence of a trait all too common even among those of scientific attainments, of failing to recognize or profit by even some of the best efforts of others. No one could turn the pages of even the few works referred to in this paper without having a much broader conception of the whole subject than is presented in any single one of them.

The third and last serious criticism that seems justified from a survey of the literature is what might be spoken of broadly as a lack of the experimental method, a failure to find out all the possible facts in the case before drawing conclusions, or before falling back on any general laws. The world's best informed physicist on the subject of acoustics could not turn his attention for the first time to the sounds over the lungs, and give an adequate explanation of their mechanism, without first engaging in experimental work on the subject, and even then many problems might remain unsolved. In our opinion, the greatest light the literature furnishes on the questions at issue has come from experimental work. As Walshe has well said, "Experiment, in truth, alone can teach in each instance what the force of conduction really is in the various complicated conditions of physical change in the lungs." It was practically this method that contributed so much to Austin Flint's great wealth of clinical knowledge, or, as his own words express it, "the significance of the signs, as regards the conditions which they severally represent, is based on the constancy of their association with the latter, our knowledge of this association being derived from examinations during life and after death." Certainly this method has been the main inspiration and guide of our own efforts. But it is to be remembered that experiments must be carefully safeguarded, or they may lead one astray, as we can testify.

If any of the above remarks appear unduly severe, or equally applicable to ourselves as to others, we can only say that we have criticized no work more carefully than our own, and have both welcomed and sought the criticism of others. No one could but be amused if he could see the list of theories we have enthusiastically held and as regretfully abandoned within the period of a few months. Moreover, whatever right our studies give us to find fault also fit us to comprehend the difficulties of the task and the efforts made to overcome them, and to appreciate that work which possesses lasting value on the part of those renowned clinicians whose example and whose spirit of true investigation will outlast all criticism. We cannot let this opportunity pass without special mention of that great man, Austin Flint, who, more than any other American, and more than any clinician since Laennec, has added to our knowledge of the physical signs of the lungs, both from the clinical and acoustic standpoints, and all this over and above his weighty load of clinical duties.

Regarding some of the theories found in the literature, we have not only experienced difficulty in weighing the evidence pro and con, but have been seriously embarrassed in trying to ascertain the full meaning of the particular hypothesis advanced. A notable example is Skoda's theory of consonance as he applies it.

Before leaving the subject of the literature it is interesting to note that while recent years have seen the mechanism of various heart sounds placed on a much clearer basis, a long period has elapsed during which comparatively little has been added to our knowledge of even some of the simplest factors concerned in the mechanism of pulmonary sounds.

OUTLINE OF THE WORK.

The scope of this work is limited to very definite fields of investigation. It is by no means a systematic treatise on physical diagnosis, nor even on the acoustic phenomena associated with the auscultation of the lungs, nor on any given subject or subjects. We have simply made the attempt to elucidate the mechanism of some auscultatory phenomena; to support the views that seemed to us correct, when such views were subject for prominent controversy, and, as far as we could, to clarify those points that still remained obscure. The consequence has been that while some subjects may seem to be too sparingly handled, others may have been pursued with a minuteness of detail that may seem superfluous. In the former case the brevity is due to the fact that the subject has been satisfactorily dealt with by others, or that all has been said on it that is known at the present time. In those cases where the detail may seem to have reached an unnecessary degree, we can only say that experience has taught us that, with ourselves as with others, it has often been the lack of detail that has led to disaster, for some of the gravest errors have resulted from the disregard of the most trivial details.

After reading some of the scientific works on the subject of the mechanism of physical signs, especially those treating of the science of acoustics as applied to auscultatory phenomena, we almost feel abashed at the simple form in which our studies are presented. We can only say that we have tried to exhibit our results in such a way as would have been useful to ourselves before we acquired the knowledge which has come with this investigation.

The sounds heard over the chest which we shall attempt to analyze are the voice sounds (spoken and whispered) and the breath sounds. The conditions in which they are to be investigated are the normal lung, pulmonary consolidation, excavation, pleural effusion, and pneumothorax.

The points we wished to investigate regarding the different sounds under these various conditions were, first, the factors concerned in their origin, and, secondly, the factors concerned in their transmission.

The Origin of Sounds Heard Over the Chest.—The term "origin" will be used in a broad sense to signify the site or sites of production of sounds, the manner in which they are produced at these sites, the general characteristics of the sounds at the place of origin, and the comparative relationship existing between the several initial sounds that may ultimately give but a single sound at the external chest surface. By the character of the sounds we mean their intensity, pitch, quality, and duration. The duration of sounds, although having an important clinical bearing, is a factor that has not been of much value in the present investigation.

As far as the general factors operative in the production of sounds audible over the chest are concerned, the general mechanism is very much the same whether one is dealing with air or fluid, either in tubes or in cavities. For example, the initial force of the diaphragm in respiration, or of the heart in the circulation, creates a current, in the one case in the air, in the other case in the fluid. This current does not contain the original sound vibrations, but, if the proper conditions arise, is made to act in such a way as to set in vibration certain tissues, these tissue vibrations being the initial sound vibrations of the sounds we hear.

The Transmission or Propagation of Sounds.—With the sounds heard over the lungs we have encountered four or five main factors affecting the original sound or sounds on their way from their points of origin to the periphery of the chest. These factors are diffusion, absorption, reflection, and resonance, and possibly interference.

Diffusion of Sound.—By diffusion is meant a diminution in the intensity of sound due to the spreading out of the sound. It is a dilution of the sound energy. If a sound originates at a point, and, owing to the non-existence of any obstructions, spreads out equally in all directions, the intensity of sound will be the same at all points equidistant from the source, *i. e.*, on the surface of a sphere whose center is at the point of origin. At the surface of a second sphere, double the area of the first, and concentric to the same point of sound origin, the vibration energy per unit of area, and hence the intensity, is halved. This is a deduction from the so-called inverse square law of acoustics, which tells us that, in a medium in which the absorption is small enough to be neglected, and which is extended enough (infinite) so that the complications introduced by its boundaries may be disregarded, the intensity of a sound varies inversely as the square of its distance from the source. A megaphone or a speaking-tube, by obstructing the passage of sounds in some directions, prevents its uniform spreading out—that is, its complete diffusion.

Diffusion is a much more important factor in reducing the intensity of sounds coming from within the chest than is generally recognized. It is the only important factor in reducing the intensity of the voice sounds after their escape from the lung in cases of uncomplicated pleural effusion.

Absorption of Sounds.—By absorption we here mean the annihilation of sound energy as such, its conversion into other forms of energy, such as heat, which may not be perceived by the ear. It is a factor diminishing sound intensities which is quite distinct from diffusion, though often confused with it. The effect of absorption on the reduction of sound intensity is very small when the sounds have relatively short distances to travel, distances of the magnitude involved in studying thoracic sounds. Even our crude experimentation indicates that very little of the diminution of the voice sounds and other sounds on their way to the periphery of the chest is due to absorption. This fact is sufficiently important and striking to deserve special emphasis.

Reflection of Sounds (Apart From Resonance).—As this factor occurs in various normal and abnormal conditions of the lungs, it operates chiefly in diminishing sound intensity, except within the bronchial tubes. Thus we encounter reflection wherever vibrations tend to pass between media of different densities. We see this strikingly as air-borne vibrations pass from within the bronchi to the bronchial walls, especially when these are incased in solid material, and from the air in the lungs to the chest-wall or to fluid. It is also manifested when air-borne vibrations encounter tense membranes, such as occur in the finer lung structure.

The loss in sound intensity as a result of the passage of the sound from one medium to another will depend upon the differences in density and elasticity of the two media, irrespective of whether the sound is going from the heavier to the lighter or from the lighter to the heavier medium, provided the sound passes from one medium to the other at the normal incidence, and provided plane surfaces come in contact or separate the two media, and provided the two media are homogeneous and infinite in extent.

As a preventive of sound loss it might be thought that the reflection of sounds from the bronchial walls back into the air within them would, by reflection, tend to preserve the initial intensity of sounds as they pass down the bronchi. Their action is rather indirect than direct. The chief effect of the bronchial walls is to prevent diffusion, thus allowing the good conducting properties of the air to operate at advantage.

Resonance.—This factor, though in a general way a less important contributor to acoustic phenomena in the chest, has frequently a place, and at times exerts a relatively powerful influence on the resultant sounds. In contrast to the factors of diffusion, absorption, and simple reflection, which affect all sounds alike, irrespective of their pitch, provided they have the same intensity, resonance acts through a selective tendency for sounds of certain pitch, affecting these sounds differently from other sounds.

It can readily be understood how the various chambers near the vocal cords can exert a resonating effect upon the vibrations at their source. The resonating effects, however, which concern us are much harder to unravel, being those that modify the sounds, not at their source, but in an entirely different locality, namely, below the upper respiratory tract, operating within the lungs or their surroundings.

Resonance is of interest in explaining auscultatory phenomena connected with the chest, chiefly in so far as it exerts a favorable influence on the transmission of vibrations of certain pitch, which vibrations may represent only some of the sounds in a complex sound, while it has no similar effect on vibrations of a different pitch or pitches.

To complicate matters, conditions favorable to the resonance of sounds of one pitch may actually diminish sounds of another pitch. In addition, sounds from different sources may come together, and thus sounds will be superimposed upon one another, and a condition known as *interference* may result. This phenomenon may result in the blurring of sounds.

In trying to apply these latter factors to pulmonary phenomena, peculiar and difficult obstacles are encountered, and our results in endeavoring to explain certain findings on the basis of these factors are much more general than specific. As far as their sphere of action in the lower respiratory tract is concerned, it seems to be limited chiefly to the air within the pulmonary tubes and cavities and the tense membranes of the normal lung, while the factors of diffusion, absorption, and reflection operate both within and external to the bronchi. As examples in which vibrations of a certain pitch appear to be affected by relatively favorable or unfavorable influences as compared to sounds of a different pitch, may be mentioned the muffled character of the normal vocal resonance, and the occurrence of whispered voice sounds over an effusion when the vocal resonance is diminished.

It is thus evident that the final sound heard over the chest may have become altered by various means in pitch or in quality or in both, from the original sound or sounds as they occur at their source. The changes in intensity of the sound as a whole are due chiefly to the factors of diffusion and reflection, and may depend to a less extent on absorption, resonance, and perhaps interference. The changes in pitch and quality, though explicable to some extent on the elimination of the weaker vibrations as the whole sound becomes more feeble, appear to be due chiefly to the factors of resonance or interference affecting certain of the vibrations, while exerting little or no influence on other vibrations going to form the complex group of vibrations which we ordinarily term a single sound.

Any one who has looked over this brief outline of the work will readily see that the task assigned can be completed only in a very crude and elementary way. In an analysis of any sound heard over the lungs we may be able to say where it is produced; to some extent how it is produced; to give some idea of the character of the initial sound, and to present the main factors concerned in the transmission of the sound or sounds on their way to form what may be a complex sound heard at the chest surface. It will be possible to draw certain strong contrasts between factors operating in one case as compared to another case. But to present any detailed or discriminating study of sounds, however much it might correspond to our wish, is beyond our scope. We are, however, most anxious that the subject, as far as developed, may rest on sure foundations, and that the boundaries of our ignorance may be as clearly marked out as those of our knowledge.

Probably the easiest way to study our subject, and certainly the briefest way to present it, is to consider first the voice sounds, spoken and whispered, and later the breath sounds. The advantage of taking up the voice sounds first is that they offer certain definite conditions with which we may start to construct our edifice. Thus, in the case of the voice, we have a known, or largely known, constant original source of sound for the individual, situated external to the lungs, and modified at its source chiefly by factors operating outside the lungs, and being constant in the same individual for both normal and pathological pulmonary conditions. This leaves us for consideration, as far as the voice sounds are concerned, chiefly the transmission of these sounds. Having developed this subject up to a certain point, we can make good use of our knowledge in trying to determine, first, the sources of those sounds that are more open to question, and, secondly, the factors concerned in the transmission of these sounds of more obscure origin. But with every effort to save repetition and confine ourselves to a single subject at a time, it will frequently be found necessary to draw on subjects outside of their own appropriate place, and to repeat under a number of headings what is presented elsewhere.

Terminology.—As far as possible we have adhered to familiar clinical terms, though from an acoustic standpoint they are at times not altogether satisfactory. Thus, the term "voice sound" is in some ways preferable to "vocal resonance," and the term "breath sound" to "breathing." Sometimes confusion arises as to whether a term signifies the location where a sound is heard or where it is produced. For us it is generally better to use such terms only in the former sense, as the source of the sound may be obscure. Thus, it is proper to speak of the normal "pulmonary" or "vesicular" respiratory murmur to signify the sound heard over the chest, but without any reference to the origin of the sound, which may be debatable. Our use of acoustic terms may not always be strictly scientific.

THE STETHOSCOPE.

It may seem superfluous to discuss so simple an instrument as the stethoscope, and yet the current descriptions are unsatisfactory, because some important features in regard to its mechanism are either omitted or misunderstood. The clinician may want to have this knowledge simply because the stethoscope is such a constant and useful companion, but, as he ordinarily applies the instrument only to the chest-wall, it is not essential for him to know its workings. For one, however, who is testing the degree of conductivity of different materials, either singly or in combination, for instance, chest-wall, air, water, distended and relaxed lung, it becomes imperative to know whether his method of listening to the sounds does furnish a satisfactory test. Thus, it would be manifestly inaccurate to conclude that air is a poor conductor of sound because one obtains weak sounds when listening with a solid wooden stethoscope to air-borne vibrations, while the same instrument gives comparatively loud sounds when applied to the chest-wall of a person breathing or speaking.

The Binaural Stethoscope.—The instrument used in the present series of experiments has been the ordinary binaural stethoscope with metal or hard-rubber bell, connected with two rubber tubes, which lead to metal tubes going to the ears. What, with such an instrument, are the course and behavior of vibrations after leaving the object tested until they reach the ear?

The Walls of the Stethoscope.—Depending on the energy of the vibrations in the object tested, more or less sound may enter the margins of the bell applied to the object tested (unless one is testing air alone), and may extend for a variable distance up the bell and into the rubber tubing, usually, however, disappearing or becoming very much diminished before the rubber tubing is reached. As these vibrations pass along the various parts of the stethoscope, exclusive of the air, they tend to send out lateral vibrations all along their course, thus reënforcing the sound already present in the air inside the stethoscope. But the main function of the actual inclosing walls of the stethoscope, from the surface tested to the ear, in the case of the various media with which we are concerned, is to prevent the escape of vibrations already in the air within the stethoscope, and to exclude extraneous sounds. A larger bell will furnish more sound than a smaller one, simply because it covers a larger area of sound-emitting surface.

The bell, depending on its size and shape, may also act to a certain extent as a resonator to those sounds having the same vibration period (pitch) as that of the air in the bell. Austin Flint noticed that the Cammann instrument, which has a bell about two inches in diameter, while of great value in determining differences of intensity and rhythm, is less suited for making comparisons regarding quality and pitch than the ear alone or the ordinary stethoscope.

A difference in pitch is obtained according to whether the mouth of the bell is closed or open when applied to an object to be tested, as is the case with sounds associated with closed and open tubes, the lower sounds being heard when, for instance, the bell margins are in contact throughout their circumference with the neck, during the auscultation of tracheal sounds, and higher pitched sounds being audible if the bell is partly raised away from the neck. This is of importance in making determinations of pitch when listening over the sides of a tube which comes in contact with the bell margins to a relatively small extent.

In testing sounds coming from an object it is important that the air in the stethoscope should be completely inclosed, which means there should be no communication with the external air at either extremity. This prevents diffusion of sound on its way from the object tested to the bell, and its escape after having entered the stethoscope.

Air the Important Feature of the Stethoscope in the Conduction of Sound.—The original paper scroll used by Laennec demonstrates the important part air can play in a stethoscope. Some sound can at times be detected without any except aërial connection between the surface tested and the stethoscope, for example, by placing the instrument close to but at no point touching the trachea of a person who is whispering, when the whispered sounds will be definitely though faintly audible. One can be more convinced of the importance of the aërial transmission of sound in the stethoscope if he listens over the trachea of a person who is whispering or speaking, the bell of the stethoscope being placed directly against the trachea, then interposes between the bell and the trachea some relatively dense material like cork or plasticene, to cause all or a large part of the sound to disappear, and then reëstablishes aërial communication by means of a very small canal between the trachea (neck) and the air within the stethoscope, when it will be found that distinct though weak sounds are restored. If the canal in the interposed material is enlarged to the caliber of the mouth of the bell of the stethoscope, the whispered sounds will be almost, if not quite, as distinct as though the stethoscope were in direct apposition to the trachea. With the spoken voice, too, one can demonstrate by the same experiment that the air is a much more important feature than the bell and tubing, though in this case the vibrations possess sufficient energy to pass to an appreciable extent from the skin to the metal portion of the bell itself. The amount of sound that passes from the object to the bell as compared to that passing to the air in the bell can be roughly estimated by closing the mouth of the bell and then applying its external surface to the object to be tested, and comparing the sound so obtained with the sound heard coming from the object when the bell is applied to its surface in the ordinary way. Under these circumstances the sound obtained coming from the external surface of the bell will, if audible at all, be much weaker than that heard by applying the bell in the customary way to the trachea or chest-wall, or other similar object to be tested.

If the bell of the stethoscope be tapped with a pencil while the mouth of the bell is alternately opened and closed by the palm of the hand, the sound heard in the latter case is many times as intense as it is in the former. This is further testimony concerning the importance of the air column in the instrument. Evidently the purpose of the open face of the bell is to permit the sound-waves to enter, and the remaining part of the instrument serves to deny them exit except to the ear.

Conduction of Sound by the Rubber Tube.—When one listens to sounds coming out of one end of a rubber tube it can be readily determined whether tube-wall conduction at any point is affecting the final sound by simply blocking the air-borne vibrations at the point to be tested. If no sound remains, all the sound must have been air-borne at this point, while if any sound persists, tube-wall conduction must have played a part. By blocking the interior of the rubber tube of a stethoscope with some suitable object, one can readily determine at what point such a procedure will abolish all sound, and this point will establish roughly where tube-wall propagation of sound ceases to be a factor in the resulting sound. In clinical work nearly all the sound will be found to be air-borne even by the time the rubber tubing is reached, corroborating Austin Flint's statement that "it is the air within the tubes which chiefly conducts the sounds." As already said, whatever vibrations pass directly from the object tested to the bell walls, and thence to the tubing, tend to reënforce the sounds already present in the air within the stethoscope.

Elasticity of the Rubber Tubing.—The more elastic the rubber tubing of the binaural stethoscope, the more will it tend to conduct such sounds as enter it from the metal attached to the bell.

The Value of Air in the Stethoscope as a Medium for Receiving Vibrations from Other Media or Combinations of Media.—Inasmuch as it is preferable to have sounds received by the tympanic membrane instead of by the bony structure of the head, it is often desirable to have vibrations transferred from objects to air, as is done by the binaural stethoscope. The fact that the air in the stethoscope may differ in either density or elasticity from the object tested, raises the question as to the value of the stethoscope as a means of testing the degree of sound conduction through different materials, either singly or in combination. Thus less sound intensity will be lost in the passage from collapsed lung to stethoscope than from liver to stethoscope. Again, if one tries to determine how much sound is lost in the passage from collapsed lung to liver, he will have to take into account the amount lost as a result of the passage from liver to stethoscope. But if one keeps constantly in mind the limitations of the instrument, he can gain useful information from it in the elucidation of our problems without endangering the general conclusions.

The Bowles Stethoscope.—This instrument is useful chiefly for the large area of sound-emitting surface that it covers. The diaphragm, in ordinary clinical work, acts principally by preventing the chest-wall from encroaching into the space beyond the diaphragm. This instrument can be used safely by one who has been thoroughly trained, but is not to be recommended for exclusive use.

The Single Stethoscope.—In its general mechanism the single stethoscope much resembles the binaural. One of its great advantages is that with it external sounds can be excluded to a greater extent than with the binaural stethoscope. The great drawbacks to the single stethoscope are that only one ear is employed in the act of listening to the object tested, and that it is a less convenient form of instrument to use, not to mention less sanitary.

The Wooden Stethoscope.—Formerly it was quite common to employ a single stethoscope constructed of thick wooden walls, with a small bore canal containing air running from the ear end to the air in the expanded bell portion of the stethoscope. In such an instrument the amount of sound propagated by the wood will depend largely on the extent of wood area in contact with the surface of the object tested. Even solid wood, for example, a six-inch length cut off an average broom-handle, will conduct respiratory sounds fairly well from the chest surface to the ear. In this case a relatively large area of wood is in contact with the chest-wall, and wood, being a good conductor, even when surrounded by air, carries the sounds with considerable intensity to the head, where some of the sound is transferred directly to the bones surrounding the ear, the remainder entering the external auditory canal. Those vibrations entering the solid portion of the head spread in all directions, some going directly to the auditory nerves, some apparently escaping into the external auditory canal, and so reaching the tympanic membrane, in the same manner as do most of the vibrations we hear. With the wooden stethoscope possessing a central area of air, the advantages of wood and air are combined. The vibrations in the wood to a certain extent reënforce those in the air.

Immediate Auscultation.—This method possesses some of the advantages and disadvantages of the single stethoscope. While preferable to the binaural stethoscope under certain conditions, it does not, as a rule, yield as clear and loud sounds as the latter instrument, at least for those familiar with both methods. External sounds are well excluded, and a large surface of the head is in contact with the chest for the reception of sounds. The fact that the sounds enter chiefly the bony portion of the head, and only to a slight extent the external auditory meatus, affects the results. When one is obliged to listen through clothing,—a necessity that should very rarely arise,—extraneous sounds can be more satisfactorily eliminated by immediate than by mediate auscultation.

According to Gee, "the vocal resonances are mostly heard best by auscultation with the ear alone; sometimes, indeed, the stethoscope altogether fails to conduct them. The same is true of auscultation of a pitch-pipe's sounds."

THE VOICE SOUNDS, SPOKEN AND WHISPERED.

The spoken and whispered voice sounds, like the breath sounds, and occasionally like râles, though ordinarily auscultated only over the chest, may be investigated in other localities, as over the trachea. For our purposes this is particularly useful because in this locality comparatively little tissue separates the interior of the respiratory tract from the stethoscope. The term "tracheal" as here used signifies only the sounds as heard over the trachea, and is not intended to convey any notion as to where these sounds are originally produced.

THE TRACHEAL (SPOKEN) VOICE SOUNDS OR TRACHEAL VOCAL RESONANCE (TRACHEOPHONY).

It is not our intention to enter into the mechanism of the spoken voice any more than to direct attention to a few facts of special interest in our work.

As heard over the trachea, the spoken voice presents distinct differences from that heard over the chest, not only in intensity, but also in quality and pitch.

One point that may be referred to in passing is the generally accepted doctrine that the loudness of the voice depends to a considerable extent upon the chamber below the vocal cords, that is, the chest with its walls and contained air, which, by their sympathetic vibrations, are supposed powerfully to reënforce the oscillations imparted to them ("American Text Book of Physiology," 1896, p. 870). This effect would probably be much more pronounced if the chest cavity contained only air, but such portion as is not filled with other structures contains lungs, and these organs are decidedly poor transmitters of sound, so that the extent to which the chest-wall can furnish increase in sound through resonance is a matter of question. Such resonating effect to a minor degree is attained by the air in the trachea and bronchi. On the other hand, in the upper respiratory tract there is every opportunity for resonation of the sounds produced by the vocal cords.

Directly over the vocal cords during speech one hears a very loud sound, probably partly because at this point vibrations are carried directly from the vibrating vocal cords through the larynx. Farther down the respiratory tract this source of sound is no longer available, and one hears only the sound from the air-borne vibrations originated by the vibrating cords.

In addition to the vibrations instituted by the vibrating vocal cords, there are, during the act of speech, vibrations produced by the respiratory current, independent of the vibrations of the tense vocal cords, which current, although usually less in volume than that of respiration, acts through a glottis much narrower than that of ordinary quiet respiration. They are evidently comparable to some of the vibrations heard during whispering when the vocal cords are closely approximated but not tense. How much of a part these vibrations play in sounds we hear either over the trachea or chest it is hard to say. Frequently it is entirely possible to distinguish them in addition to special sounds of speech. Apparently they reënforce some of the other sounds, and at times conditions may be relatively more favorable, as far as intensity goes, for the transmission of these sounds than of the spoken sounds proper.

Listening over the trachea or larynx is an admirable way to study a number of sounds—not only the spoken sounds, but those of breathing and whispering. The tracheal wall being relatively thin, the sounds, preserving considerable of their original intensity and other characteristics, lend themselves particularly to the investigating of the effects that modify sounds after leaving their place of origin, and in this way furnish clues as to how the sounds heard over the chest become modified on their way from the interior of the body. We can in this way demonstrate, for instance, how sounds may become altered, first in intensity, and secondly in pitch and quality. If one, for example, places a piece of cork between the trachea and the stethoscope, the sounds will be reduced, and by means of this reduction some sounds may be entirely eliminated, which will render the resultant sound altered in other respects besides intensity. Again, depending upon the size and shape of the cork, sounds of one pitch will disappear to a greater extent than those of another pitch, which will also greatly modify the character of the sound as heard. Thus a small thin disc of cork placed between the trachea and the stethoscope will reduce the general intensity of the voice sounds of a person with a low-pitched voice much more, relatively, than the whispered sounds of the same individual, provided they are high pitched, and the voice sounds themselves will become higher in pitch. Another striking example is the marked degree of egophony that can sometimes be obtained by placing a thin piece of cork or other material between the larynx and stethoscope. The results may be due to the fact that the high-pitched nasal tones are to a certain extent resonated, and therefore relatively less diminished, than the other low-pitched sounds, and therefore are heard with unusual distinctness. It is this factor of the different degrees of sound diminution for different bodies or air chambers that may play an important rôle in some of the normal and abnormal sounds we hear over the chest, and may help to explain why sometimes we have whispering pectoriloquy even when the vocal resonance is actually diminished.

It is of some importance to know how the voice sounds heard over the trachea compare with those heard coming from the mouth, not so much in intensity as in quality and pitch. When a stethoscope is applied to the trachea and sufficiently long tubing employed to avoid confusion from the sounds coming from the mouth, the sound is always that of muffled speech, showing that some muffling of the sounds heard over the chest may occur independently of the lung itself. With some individuals one can understand, by careful attention, what is being said, but it takes some effort. In other individuals such fine discrimination is impossible. The whispering sounds under these conditions are apt to be less clear than the spoken ones.

We shall not in this place enter into a description of the mode of origin of the spoken voice, which is to be sought in full elsewhere. The important thing to be emphasized here is that the voice sound vibrations that give rise to the sounds heard over the trachea give rise also to the vibrations heard over the chest. Some of these vibrations are air-borne from the vocal cords: others may extend for a variable distance from the laryngeal walls into the tracheal walls.

The sounds heard over the trachea differ greatly from those over the normal chest, both in intensity and in other respects—a difference that may be much less marked in certain pathological processes.

The spoken sounds lend themselves particularly to the study of sound transmission through the lungs and chest-wall, because, at least at their original site, the vocal cords, they are entirely extrapulmonary, and because we have so definite an idea as to their original site of origin, and to a great extent of their mode of production.

THE TRACHEAL WHISPERED VOICE SOUNDS.

On listening directly over the trachea during the act of ordinary expiratory whispering, a sound is heard which lends itself to the study of the transmission of sounds through the chest, much as do the spoken sounds in this region. Compared to the breath sounds heard over the trachea, the whispered sounds are louder than the breath sounds during quiet respiration, and usually louder than the breath sounds during moderately forced respiration. Their intensity may be made to vary with the degree of approximation of the vocal cords, and with the amount of air expired per unit of time. The exact words whispered are less easily distinguished over the trachea than are the spoken words in this situation. Beyond these general remarks it is not necessary for our purposes to go further into the character of the tracheal whispered sounds.

An inspiratory whispered sound, like an inspiratory spoken sound, may be produced. It is much weaker and less satisfactory than the expiratory sound.

The Source of the Whispered Voice Sounds Over the Trachea.—The whispered voice sounds are generally described as being produced in the same way as the spoken sounds, except that the glottis is passive. This is partially inaccurate, especially in regard to the vocal cords, which, though not as tense as in speaking, still, in most cases of whispering, will be found to move closer together than in ordinary expiration, and which, by a little effort, may be brought quite close together, with a considerable increase in sound. The sounds produced by the vocal cords during speech are supplanted in whispering by sounds of a different character, but still partially made by the vocal cords, which have become less tense and wider apart. If one keeps the vocal cords altogether at rest during whispering, a large part of the sound uttered becomes almost inaudible. Thus, if one attempts to say a vowel with the glottis entirely "inactive," little is heard over the trachea or at the mouth except an expiratory sound, weakened in proportion to the feebleness of the whispered breathing. When, on the other hand, distinct expiratory whispering is produced, the vocal cords come closer together, producing sounds which are affected by resonance in the respiratory chambers, much as in the case of spoken sounds. Some sounds, even in speech, may be produced entirely without the aid of the vocal cords, such as "ss," which is made at the teeth, and the German "ch," which is partly formed by the structures of the soft palate.

From the practical standpoint, the whispering as heard over the trachea in most cases has a marked glottic element in it, but the degree to which the glottis contributes to the sound will be found to vary much in different individuals, and will explain in part the differences in the whispering sounds encountered in different persons.

How much the glottic sound is formed by the impact of the air on the free margins of the cords, and how much is due to the passage of air from the narrow glottis to the wider space above, we cannot say, but we believe the former to be a very important factor in many cases.

The Whispered Sounds are Produced in the Upper Respiratory Tract.—The really important thing to be determined, however, in regard to the origin of the whispered sounds, is whether they are produced in the upper respiratory tract, particularly whether they are produced above the bronchi and lungs, to the extent that the spoken sounds arise in the upper respiratory tract, or whether their origin occurs at all in the lower respiratory tract, for on this solution will depend the value of the sound for purposes of study of sound transmission through the lungs and chest-wall. Whatever sounds are produced in the lower respiratory tract during expiratory whispering must be simply respiratory sounds, and must be as much weaker than the ordinary sounds produced during simple expiration without whispering, as the combined amount and rate of air during whispering are less than those of ordinary or forced respiration. We conclude, therefore, that any sounds produced in the lower respiratory tract during whispering will usually be less intense than those produced in the same region during expiration. As to the intensity of the sounds produced in the lower respiratory tract during expiration, we may anticipate what will be dealt with more fully under the subject of the breath sounds, by stating that our evidence indicates that very little, if any, sound is produced by the respiratory currents in the lower respiratory tract during expiration, at least when the lungs are normal, and therefore under similar normal conditions the sounds produced below the trachea during whispering must be even less intense than during expiration—certainly not loud enough to compete, so to speak, with the sounds produced in the upper respiratory tract during whispering. And even if there is evidence for there being more sound produced in the lungs when pathological processes are present than under normal conditions, still, the reduction in amount of air flow during whispering as compared to breathing would tend to minimize any sound produced in the lower respiratory tract during whispering.

We conclude, then, that both in normal and pathological conditions the whispered sounds may be considered to arise in the upper respiratory passages, at least as much as do the spoken sounds. We believe that in most cases the glottis is an important site of origin for many of the whispered sounds.

THE NORMAL OR PULMONARY VOICE SOUNDS, OR VOCAL RESONANCE.

Granting that we have fairly fixed sites of origin for the spoken voice sounds as heard over the chest, our task is restricted to determining how these original sounds become affected in their transmission through the lung and chest-wall, to give rise to the very different sounds heard in this latter locality—different, especially, from the voice sounds as heard over the trachea. The original sounds during their passage to the chest surface suffer changes in intensity, pitch, and quality. The factors concerned in effecting these changes in the voice sounds are to a considerable extent the same as those affecting whispered sounds, breath sounds, and râles on their way from their sites of origin to the periphery of the chest.

As contrasted with the tracheal voice sounds (tracheophony), the normal chest vocal resonance is much weaker; according to Flint, it is not even constantly present in normal individuals, at times being absent over the entire chest. The sound is described as more distant and diffused. The pitch is lower than over the trachea. The quality is distinctly altered, as evidenced by the fact that the distinct articulations discernible over the tracheæ of many people are replaced by a rumbling, humming sound that is often not sufficiently distinctive to inform the hearer that syllables of different kinds are being uttered. The pulmonary sound is what we may call a much more muffled voice sound than the tracheal sound.

The Intensity of Normal Vocal Resonance.—The first subject to be taken up in treating of vocal resonance is that of intensity. What we find of value in regard to the intensity of normal vocal resonance will be found of more or less assistance when applied to other investigations. The real significance of the various factors affecting the vocal sounds after they enter the normal lungs can be appreciated only by comparing them with factors operative in the pathological conditions to be treated subsequently. The subject may be introduced by allusion to some of the more prominent views held in regard to the general subject of the intensity of sounds audible over the lungs.

Literature Dealing with the Intensity of Sounds.—Most of the current explanations for the varying intensities of sounds heard over the lungs under different conditions have rested on a few principles, some of them simple and plain, others not so readily intelligible. Laennec, speaking of bronchial breathing, says that it is "louder and more distinct in proportion as the lung is more condensed and thereby becomes a better conductor of sound." In another place he asserts that the "loose texture of the lungs, rendered still more rare by its intermixture with air, is a bad conductor of sound." As a matter of fact, when the lung is "loose," that is, in a relaxed state, it is a fairly good conductor, though a much poorer one when in a state of normal tension. Laennec's views, entire or in part or with modifications, hold sway generally in French- and English-speaking countries at the present time.

Thus Gee says: "The conducting power is increased by whatever increases the homogeneity of the structure of the lung, or, in other words, by whatever makes the lung approach nearer to simple solid or simple air." The principle of heterogeneity, however applicable in the present instance, does not always operate to cause much reduction in sound. Thus sounds may pass between two such different media physically as fluid and tissue without suffering much diminution.

Skoda, whose views in part have considerable influence in Germany to-day, combated Laennec's theories, and sought explanation for the louder sounds over consolidation rather in an increase in the sounds within the bronchi of solid lung, than in conditions more favorable to conduction outside of the bronchi. In order to understand Skoda fully one must read his explanations at length, and he will probably have some difficulty even then. An indication of his ideas can be gathered from the following: "The conditions requisite for the production of increased consonance of the voice in the bronchial tubes, which run into the parenchyma of the lungs, are these: Either the walls of the tubes must be cartilaginous, or, if membranous, must be very dense, or the tissues of the lung around the tubes must be deprived of air; in any of these conditions the walls of the bronchial tubes will reflect sound more strongly than in their normal condition." It is true that the intensity of sounds within a space will vary to some extent with the nature of the walls inclosing it. Sounds within a portion of intestine, as Skoda has shown, are louder when the intestine is under water than when it is in the air, and the same thing may be demonstrated for a balloon in water and in air, or for a lung under water and in the air. But while under these conditions sound reflection is favored, and the sounds become louder within the inclosed spaces, the egress of sound becomes proportionately hindered. One might reason conversely, that because there is more opportunity for sound to escape from within the bronchi of normal lungs, the sound over them should be louder. Skoda has not shown how much louder the sounds are within bronchi surrounded by consolidation, and has certainly furnished no convincing evidence that an increase of sound within the bronchi explains the louder sounds at the chest surface.

Walshe strongly disagrees with Skoda's views, but, like him, believes that the louder sounds over solid lung are due to an increase of sound within the bronchi, invoking to his support the laws of conduction and echo. In discussing the subject of vocal resonance he says: "There seem to be three ways, as far as are now known, in which a sound may be reënforced beyond the seat of its production, by what may be called unison-resonance, by consonance, and by echo. In all three reflection of sound is concerned, but the laws of that reflection are in each case different."

Austin Flint, who stands among the pioneers in developing both the practical and theoretical aspects of pulmonary sounds, gives the following explanation for the louder sounds over the solid as compared to the normal lung: "Suppose a case of pneumonia in the second stage, one lobe, at least, being completely solidified. The solidified lobe is enlarged in volume nearly or quite to the limit of the expansion at the end of the inspiratory act. Its volume does not diminish with expiration, but remains the same in the inspiratory and the expiratory act. The respiratory movements on the affected side are more or less restricted. Now, the voice is produced by the breath in the act of expiration, that is, it is produced when the current of air is passing from the bronchial tubes of the healthy lung, in consequence of the diminution in the volume of this lung by the contraction of the thoracic space. It seems fair to assume that, under these circumstances, the bronchial tubes on the affected side contain more air than on the healthy side, and that there is less of a current of air in the expiratory act toward the trachea and larynx. Do not these points of difference account for a better conduction of the voice by air within the bronchial tubes on the affected side?" Even more than the question itself, the pages leading up to this conclusion reveal Flint's uncertainty as to the validity of this conclusion. Evidence is lacking to show that any such difference in sound intensity within the bronchi of the solid lung, as compared to that of the normal lung, could cause the louder sounds over the chest containing the solid lung. If one listens to sounds coming through a tube, he will observe that considerable diminution in the caliber of the tube is necessary before any considerable diminution in the sound is detected. And as to the effect of air currents, it will be shown later that the evidence indicates that even in the absence of all such currents the sounds are still weaker over the normal chest than the chest containing solid lung.

An explanation, not elsewhere encountered, for lessening the sounds within the bronchi of the normal as compared to the solid lung, might be sought in the continuation, in the case of the normal lung, of the terminal bronchi into the air-spaces beyond.

Any greater degree of intensity of sound that may occur within the bronchi of the affected side, as compared to the normal lung, has not been proved to be of sufficient degree to account for the marked differences encountered over normal and pneumonic chests. Moreover, any marked increase in sound in one set of bronchi would tend to spread to other portions of the lungs. More time might be spent in a consideration of the intensity of sounds within the bronchi in health and disease, if conditions external to the interior of the bronchi were lacking to explain, for the most part, the louder sounds over the diseased as compared to the normal chest.

Bullar, who has apparently been accorded but a single reference in the literature, has contributed to this subject a most important fact. He showed that when sounds are introduced into the bronchus of a normal lung, they are much louder at its surface when the lung is in a relaxed state than in an inflated state, and considered the poor conducting properties of distended lung the cause for the less intense sound heard over the normal chest as compared to the chest overlying solid lung.

It is noteworthy that the general tendency has been, except on the part of Bullar, to try to find factors favorable to the louder sounds over the area covering the consolidated lung, rather than those favoring the weakening of sounds over the normal lung.

The Factors Responsible for the Degree of Intensity Occurring in Normal Vocal Resonance.—Why is this sound so much weaker than the tracheal vocal resonance? The factors responsible for this reduction may be grouped into those that affect all sounds of the same intensity alike, and those that influence some sounds in different ways from other sounds. The first group includes only two factors of great importance, those of diffusion and reflection, and the second, those of resonance and interference. It is the first group that can be most easily applied, and this group will receive our first attention. But even with these relatively simple factors, we are constantly beset with limitations in trying to apply them under various conditions, normal and pathological. While we can fairly satisfactorily say at what points each of the first two factors, diffusion and reflection, are effective, we can offer only very rough quantitative estimates of the amount of sound reduction produced by them under different circumstances.

In dealing with the voice sound we shall treat of it only from the time it becomes a purely air-borne sound, that is, from that point where first a blocking of the respiratory canal would obliterate all sound beyond, as is done by a foreign body in a bronchus. Just where this point is, that is, where the sounds in the tube-walls cease to reënforce the sound within the inclosed air, and where what vibrations the tube-walls possess can come only from the contained air, we do not know. The point will, of course, vary with the character of the voice and other factors, but because of the poor opportunities for the tracheal wall to conduct sounds, we assume that the voice vibrations, as far as the interior of the respiratory tubes is concerned, are entirely air conducted before the bronchi are reached.

The Structures and Media Traversed by the Vocal Vibrations.—As the vocal vibrations extend into the various tubes of the respiratory tract, they tend to disseminate in all directions, some penetrating the adjacent tube-walls and others passing farther along within the tubes. How much sound finally enters the air-sacs by the intratubal route—that is, are carried solely by the air through the bronchi and their terminations and finally to the air-sacs—we cannot say, but we believe the amount to be small, partly because of the small caliber of the smaller bronchi, and partly because, as the bronchi become smaller, their walls become more attenuated, and sound can more readily escape through them. After leaving the air within the respiratory tubes and their blind terminations, the vibrations pass to the walls of these structures, that is, of the bronchi, large and small, of the atria, and of the air-sacs, or rather the air-cells. The vibrations on leaving the walls of these structures pass to the surrounding parenchymatous lung structure and its contained air. This holds true except for those air-cells immediately beneath the pleura, which have, for part of their wall, practically the chest-wall. Having traversed the membranous structure and its contained air that surrounds the bronchi, the vibrations next enter the chest-wall, which serves as the final stage of their passage before reaching the external air. In other words, almost all the sound has to traverse air and membranous structure before reaching the chest-wall.

Knowing the routes of travel of these vibrations, we can form some general idea of where the general sound-reducing principles previously alluded to become effective. Diffusion, though variously effective,—much more effective outside the bronchi than within them,—is a constant process, and, because the chest surface is much larger than the tracheal, we expect sound to be diminished through diffusion under these circumstances. This process is, of course, materially reduced by the tubal structure of the lungs, which acts to a certain extent after the manner of speaking-tubes, by carrying, with comparatively little diminution, the vibrations much nearer to the chest surface than is possible for the trachea itself to do.

The factor of absorption of sound occurs all along the route, but plays little part, as the individual media with which we are concerned are not poor conductors of sound. This subject will be pursued further in another place.

The factor of reflection is chiefly operative, first, as the air-borne vibrations come in contact with the bronchial walls; secondly, where the vibrations in the bronchial walls come in contact with the surrounding air in the vesicles; thirdly, where the vibrations in the air within the air-cells come in contact with the tense membranous walls of these structures; and, fourthly, where the vibrations in the air immediately beneath the pleura come in contact with what we may consider as the chest-wall, that is, with the beginning of the tissue that is continuous with the chest-wall.

Methods of Testing Objects for their Effect on the Intensity of Sounds Passing Through Them.—Our methods, though very crude from a scientific standpoint, seemed to be the best that were readily available, and have apparently served their purpose of giving satisfactory general conclusions on some points.

Sources of Sound.—Dependence has been placed chiefly on two sources of sound—the tuning-fork and the T-glass tube, each used in a variety of ways.

The *vibrating tuning-fork* has been placed with its base directly on the object to be tested, or the base has been placed in one end of a rubber tube, the distal end of the tube being placed tight against the surface of the object to be tested, or else the tube leading from the tuning-fork has been placed in communication with the interior of the object, for example, being inserted into the trachea,—fitting tightly into it,—if the lung is to be tested in this way. The tube may either be so long that all vibrations on reaching the object are air-borne, or may be short enough to allow of tube-wall conduction. One should know which of these two conditions is operative in the particular case. Tube-wall conduction may be tested for by properly occluding the tube so as to prevent aërial communication between the two portions. All sound will cease in the distal portion if wall conduction is not present at the point of constriction. The distal end of the tube may be covered with a rubber tissue diaphragm, or, if the walls themselves are to be tested, the distal opening may be closed by a clamp. If several tubes communicate with a tube containing tuning-fork vibrations, one must consider the possibility that these vibrations may be reënforced or interfered with by the air in the tubes more distant from the tuning-fork.

The T-glass Tube.—In this case air is forced through the horizontal limbs of the T-glass tube, the vertical limb being connected with the object to be tested. For convenience rubber tubes are usually attached to the glass tubes to make the tubes longer. One can blow moderately through the horizontal limbs, or may whisper into one of them by means of a funnel, or even speak into it. Or one of the horizontal limbs may be connected with a compressed-air or gas jet. When sounds are introduced in this way into an object from a T-glass tube, they are composed, theoretically, of four distinct sounds—First and second, the sounds at either end of the horizontal portion; third, the sound made as the air passes across the vertical limb of the T-glass tube, and fourth, the sound made by the air passing through the horizontal portion. The third and fourth sources of vibrations would ordinarily be too weak to produce an audible sound. The sound at the open end of the horizontal portion may be quite loud, but the sounds at either end of the horizontal portion of the T-glass tube may be eliminated by attaching sufficiently long tubes. Fairly weak sounds are obtained at the open end of the horizontal limb if the ordinary respiratory rate is employed. Whatever sound is produced as the air, passing through the horizontal portion, crosses the mouth of the vertical limb, will be almost or entirely obscured by the louder sounds at the free opening of the horizontal limb. The caliber and length of the vertical limb, or of the vertical limb and the tubal structure attached, will variously affect the pitch of sounds coming into it from the horizontal portion of the T-tube. If one is obliged to do the testing unaided, the T-glass tube is a very convenient device, as it leaves the hands free. Under these circumstances the spoken voice is less satisfactory than either blowing or whispering. With the blowing or whispering into the T-glass tube—a funnel being used to receive the whisper —the sound heard over the object being tested will be either a blowing, somewhat bronchial sound, produced chiefly at the free end of the horizontal limb of the glass tube, or a whispering sound. As with the tuning-fork, the rubber tube going to the object to be tested may be placed directly against the object, or inserted into a canal passing to the interior of the object, or the distal end of the tube may be covered with a rubber tissue diaphragm or held closed with a clamp.

It will be seen that with both sources of sound—the tuning-fork and the T-glass tube—the air within the rubber tube connecting the tuning-fork or the T-glass tube with the object to be tested has no free communication with the air in general at its distal end, because this distal end is either placed tight against the surface of the object, or within a canal or cavity ending blindly in the object, as, for example, when the tube is inserted into the trachea attached to the lungs to be tested.

As the vibrations pass on their way from the rubber tube to the object to be tested, they may leave the tube by way of the distal opening, or they may also leave it by passing through the rubber margin around the opening, if the tube-wall is conducting sound at this place, the distal end of the tube being placed against the object to be tested. Objects to be tested may also be made to surround the tube on all sides, coming in close contact with it, the distal opening of the tube being closed or open.

In the main, two procedures have been followed in regard to the course of the vibrations on their way from their point of entrance into the object to the point where the intensity is to be tested. The vibrations have been introduced into the object either at its surface or into the interior of the object, the object being tested at some point on its surface. Thus in the case of a lung the vibrations may enter at the surface, or internally through the interior of the trachea. In the case of gelatin they may enter at its surface, or by way of a canal made into its interior, the surface then being tested. Internal introduction of sound approaches more closely to actual clinical conditions, and in the case of objects with a tense surface, like distended lung, surface conduction is avoided.

Sound Reception.—This has generally been carried on by the binaural stethoscope. While this is a comparatively crude method for testing sound conduction, it gives some fairly satisfactory general results for present purposes. It may be objected that the bell of the stethoscope and the air in it will admit sounds with the least loss of intensity from those objects which approach nearest in density to the bell or the air. This difficulty and the precautions to be used to overcome it have already been discussed in speaking of the stethoscope.

Our experimental work relating to sound transmission under normal conditions has been pursued along the following general lines of investigation:

1. The various individual media encountered (air, fluid, and tissue), as to their capacity for sound conduction and absorption.
2. The effect on sound transmission of different media in combination.
3. The effect on sound transmission of normal lung in the normally distended state.
4. The effect on sound transmission of normal lung in the relaxed state.
5. The various factors operative in the transmission of sounds through normal lungs distended and relaxed, with especial reference to tense membranes.
6. The effect on sound intensity due to its passage from lung to chest-wall.

The Effect on Sound Conduction of the Different Individual Media Involved.—The individual media concerning us are either relatively simple, like air, or complex, like liver. Where no special object was to be gained by separating a medium into its simpler components, the tests have been applied only to the material as a whole.

Omitting from consideration bone and fat, the media of interest to us may be divided physically into gases, chiefly air, fluids, chiefly water, and gels, of which muscle, consolidated lung, and gelatin in the firm or "solid" —not hard—state furnish examples.

Air.—That air is a very light medium (sp. gr., 0.001293) and a very good conductor of sound is too well known to need any experimental demonstration here.

Water.—That water is a very dense medium compared to air is also well known, but it is not so well known that water, too, is an excellent conductor of sound. Water does not specially concern us in a discussion of normal lungs, as we do not test for its conductivity by itself, but only the conductivity of the more complex materials of which it forms a part. In passing it may be remarked that the presence of water in soft tissue, which is a gel, does not necessarily decrease the sound conductivity to any extent, partly because water is itself a good conductor, and partly because vibrations pass from gels to water and from water to gels with comparatively slight loss of intensity. This subject is more fully taken up under Pleural Effusions.

Tissues.—The study of tissues appears at first sight as complicated as the tissues are physically complex. The tissues are certainly anything but homogeneous, whether we consider their fluid or solid contents, and whether we study the architecture of the cells. Strangely enough, however, it would appear that the soft, "solid" tissues with which we are most concerned are good conductors of sound, despite their lack of homogeneity. This apparent inconsistency is probably to be explained on the fairly uniform densities and elasticities of the different elements entering into the formation of the tissues.

The tissues of special interest in connection with normal sounds are muscle, as representative of the chest-wall, trachea, bronchi, except the terminal membranous portions, and the membranous structure of the lung in the normally distended state, including the walls of the membranous bronchi and the membranous structure distal to them, such as the walls of the atria and air-cells. For elucidation of the subject the study of other tissues is also favorable, such as those of the distensible portion of the normal lung in the relaxed state, and also the study of soft tissues in general.

Soft tissues are for the most part composed chiefly, except for their fluid contents, of substances known as gels, of which firm gelatin in pure form is a typical example. These gels are known to have certain physical characteristics in common, and these are said to extend to some of their acoustic properties, a statement in line with the results of our experimental work.

For convenience we will discuss some of the acoustic features of pathological tissue at this time, and also of firm gelatin in a 10 to 20 per cent. strength, as it is a useful substitute for soft tissue.

The Term "Solid."—It may be well, before proceeding further, to insist that such structures as tissue, normal and pathological, though frequently called solid, may be very different acoustically and in other physical respects from other solid substances, such as wood, metal, or glass.

The attempt will be made to show, largely from experimental work, three very important facts regarding the solid substances with which we are concerned: first, as to their conductivity, that they are all good conductors of sound, and that each one fairly parallels the others in this respect, and, secondly, as to the passage of sounds between them, that when they are placed in contact with one another they transmit sound, distance for distance, with approximately the same intensity as a single one of these substances, indicating that no considerable "break" occurs between them, and, thirdly, as to the passage of sounds between these and other media, that sound passes from any one of all these media to any other single medium like air, with an equivalent loss in sound intensity, and in the reverse direction from any medium like air an equal loss is sustained, irrespective of which of the substances is to receive the vibrations from the air. If the tissues, normal and pathological, possess these three characteristics, that they conduct sounds about equally well, and that little or no sound is lost simply from its passage from one of these substances to another, and that the different media behave alike among themselves in relation to other media, we may then regard them all as constituting for our purposes practically one and the same medium.

Gelatin in the Firm State.—This substance was recommended for use by Dr. Kite as being a form of gel in a pure state. It has been used extensively in the present work, usually in 10 to 20 per cent. strength. Its conductivity has been tested by methods previously described, that is, with vibrations coming from a rubber tube, the opposite end of which holds either the base of a vibrating tuning-fork or the vertical limb of a T-glass tube, through the horizontal limbs of which one either blows or whispers, or through which an assistant speaks. The sound enters the gelatin either externally at its surface, or internally through a tube-like canal made to represent a bronchus. Under any of these conditions, provided the sound coming from the tuning-fork or the T-glass tube is moderate in intensity, such as would be made by blowing or whispering into the tube with moderate intensity, all sound disappears within several inches, being very much weakened by passing through two inches of the gelatin. The sounds appear to be louder, distance for distance, if they enter the gelatin through a canal going in to its interior than if they are introduced externally. Generally speaking, gelatin is found to resemble fairly closely, in its conductivity or absorbability, the other substances concerning us that are composed largely of gel, for instance, muscle or liver.

Gelatin is not a poor conductor, but a very good conductor. It might be supposed that gelatin is a poor conductor because a sound passing through a block of gelatin varies so much in intensity, even if the actual differences in distance through which the sound has to travel are comparatively slight. The deintensification of the sounds, however, does not depend on the distance traversed in the gelatin, that is, on the absorption of sound, but depends upon the character of the boundaries of the gelatin. As the block of gelatin enlarges, even if in only one direction, its surface area increases, and diffusion, not absorption, of sounds is promoted. In the case of a medium known to be an excellent conductor of sound, for example, water, a marked loss of intensity can be demonstrated if the boundary and other conditions are made to resemble as closely as possible the conditions of the gelatin showing a marked diminution of sounds passing through it.

If a small balloon is filled (not distended) with water and placed against the trachea of a person speaking, the sounds on the opposite side of the balloon will be distinctly weaker than over the neck, as tested by the stethoscope. A second balloon will reduce the sounds still more, and a third one will nearly obliterate them. By proper manipulations the degree of sound lost as it passes from one balloon to another can be reduced to a minimum. The remainder of the loss is due, not to absorption, but to diffusion. Again, if sounds are introduced into water at the bottom of a cylindrical metal vessel, they will notably decrease as the vessel becomes filled with water. Other examples along this line will be offered in treating of pleural effusion.

When one eliminates diffusion as a source of loss of sound, gelatin and tissues appear in their true light of good conductors. This is demonstrated clinically in cases of consolidation, in which one obtains relatively loud sounds over the chest compared to those heard over the trachea, in spite of the favorable opportunities for diffusion. Experimentally, sounds introduced within canals in gelatin or liver are transmitted relatively loudly through varying distances in these substances, when one makes allowance for the sound-diluting effects of diffusion, and for the loss sustained as the vibrations pass from these substances to the stethoscope. When one employs a cylindrical block of gelatin six inches in height, with a transverse diameter of eight inches, and makes a narrow canal running from the center of the upper surface vertically downward, and passing nearly to the lower surface of the gelatin, and then introduces sounds into the canal by blowing through the horizontal limbs of a T-glass tube, while the vertical limb is connected to the opening in the canal in the gelatin, sounds are clearly transmitted through the four inches of gelatin separating the canal from the outer curved surface of the gelatin. Voice sounds introduced into the gelatin in this way are transmitted loudly through it. Sounds are also transmitted well through the gelatin without the intervention of air, demonstrating that Skoda's consonance, and other intrabronchial and intracanalicular increases in sound, are not necessary to explain the relatively loud sounds we hear coming through solid tissue and gelatin.

If one conducts an experiment much like the above, but substitutes a large beef liver for the gelatin, he will obtain results not greatly differing from the above, provided sounds are introduced into the liver as they were into the gelatin. What differences may occur do not have any important bearing on the broad general conclusions associated with our problem.

We have tried to demonstrate the good conductivity of gelatin by showing that, under fairly similar conditions, sounds of much the same intensity will be heard coming from the gelatin as from the fluid, which is known to be a good conductor. This similarity of results holds good in all our experiments. Thus, if one uses two narrow cylindrical paper boxes, the one containing gelatin molded in the box and the other containing water in equal amount (about 750 c.c.), and places first the bottom of one box and then the bottom of the other box in contact with the surface of a body of water containing sound vibrations, sounds of equal or nearly equal intensity will be obtained with the stethoscope applied to the upper surfaces of the gelatin and the water in the boxes. If two large, equal-sized jars are used containing equal amounts, one of gelatin and the other of water, and sounds of equal intensity are made at the external surface of the jars, sounds will be heard at the upper surfaces of the gelatin and the water not differing greatly in intensity.

Gelatin being a good conductor of sound and therefore presumably being elastic, we would expect sound vibrations to pass between it and water, which is of nearly the same specific gravity as water, with very little loss in intensity. This is apparently borne out by our experiments. Now, most of the soft tissues, normal and pathological, are made up of cells, which are a form of gel, and closely allied physically in many ways to gelatin, and are associated with a certain amount of fluid, so that we would suppose that tissues with their contained fluid would act as a homogeneous medium, and, possessing a marked degree of elasticity, would readily transmit sounds. This is apparently what occurs.

The Chest-wall.—This has not been studied by itself more than to note a rapid increase in sound intensity as more and more of the muscle is removed from animals, fetal and adult, the sound originally having been introduced into the trachea.

Muscle.—Cardiac muscle has been chiefly employed. What evidence has been obtained demonstrates that, as a conductor of sound, it in general resembles gelatin and liver.

Trachea and Bronchi.—It has been impossible to obtain a sufficiently thick layer of tracheal or bronchial material for satisfactory tests. We presume the walls of the trachea and bronchi resemble other soft tissues acoustically.

Liver.—This has not been found to differ greatly from gelatin in its results as to sound intensity, though at times it has appeared to have a more weakening effect on the vibrations.

Fetal Lung Tissue.—Fetal calf lungs almost at term have been used. Sounds introduced externally are heard less plainly than if introduced by the same tube into the trachea, provided the bronchi are patulous, which condition can best be secured by leaving the lungs in the chest. The chest-wall may then be cut away with just enough remaining to prevent collapse of the lung. Under these circumstances surprisingly loud sounds are heard, which is also true if one listens at the external surface of the chest-wall, even the hair being allowed to remain. The sounds coming from the surface of a fetal lung, however, become very much diminished if they have to pass through a second fetal lung overlying the first one.

Consolidated Lung "Tissue."—The study of "solid" lung "tissue" is fraught with difficulties and has resulted in considerable confusion and error. Allusion has already been made to the fact that, though this substance is in one sense "solid," in its conductivity for sounds it is in a very different physical state from solids of the type of wood or metal. A very annoying source of difficulty is to find a lung that gave during life markedly increased vocal resonance, permitting no audible sounds to reach the chest surface after death,—the sounds being introduced into the trachea,—because of the obstruction caused by secretion, or mixed secretion and air. After removal of the lungs from the body there is often more or less collapse, which favors occlusion of the bronchi at various points. Uncertainty may also arise because of the difficulty of distinguishing clinically whether a portion of lung is completely hepatized or not, that is, whether it is entirely airless.

A mistake that has been frequently made, and sometimes by noted authorities, has been to draw conclusions about the relative conductivity of normal lung and solid lung, from a comparison of solid and relaxed lung, relaxed lung being a decidedly better conductor than distended lung. There is no record of there having been made any comparison between the solid lung and the normal lung in a state of normal tension.

Properly to test the conductivity of a solid lung the chest-wall should be removed over a portion of the solid part, just enough of the chest over this area being left to maintain the lung in position. A series of lungs should be tested in this way. While we lack such experiments, we have enough evidence from other facts, and from certain general principles, to form a pretty clear idea how such "solid" material affects the intensity of sounds passing through it. When we make allowance for the amount of sound lost in traversing the chest-wall, and in passing from the chest-wall to the stethoscope, we conclude that solid lung tissue is a very good conductor of sound.

Our experimental work indicates that a solid lung containing no air in the vesicles resembles normal body tissues and gelatin as a conductor of sound. That this solid material is composed largely of gel, that is, of cells, that in density and other physical characters it much resembles the normal soft tissues of the body, that in states of red and gray hepatization and of fibroid and of malignant change the sounds at the chest surface are often alike, lead one to believe that solid lung, as long as no air is present in the vesicles, has close acoustic relationships to the type of media under consideration. Moreover, there is no considerable contrary evidence to our inference that solid lung tissue closely resembles liver, muscle, and gelatin acoustically.

With the demonstration of tissue, normal and pathological, as a good conductor of sound, the factor of absorption of sound on the part of tissue becomes relatively insignificant as a cause of sound reduction in the chest, and our problem becomes correspondingly simplified.

Membranous Tissue of the Normal Lung in a Relaxed State.—The tissue of the relaxed lung, apart from the air, may be inferred to have much the same acoustic properties as other soft tissues. It occurs *en masse* in the adult when a normal lung has been compressed for a sufficient period of time for the air in it to become eliminated. We have studied it chiefly in the lung of the fetus shortly before term, with results above set forth, indicating that such tissue does closely resemble other soft (or "solid") tissues from an acoustic standpoint. Such a fetal lung can readily be inflated. However, in the relaxed lung containing air the membranous tissue is so thin, and is so intimately associated with the air which it incloses and partitions, that we cannot infer just what its behavior toward the passage of sound is, and must limit our conclusions considerably to knowledge gained from the study of the whole lung.

The Membranous Tissue of the Normal Lung in the Normally Distended State.—What has just been said in regard to the membranous tissue of relaxed lung applies also to that of distended lung, that is, we cannot entirely divorce the action of the membranous tissue on sounds from the combined action of the tissue and air of the lung. The distended tissue itself, if thin, would be a better conductor than the relaxed tissue, because of its tension, just as a piece of rubber becomes more elastic, and therefore a better conductor, when put on the stretch, that is, provided the same piece of tissue or of rubber is employed, and provided they are tested in air. If the base of a vibrating tuning-fork is applied at one point to a narrow strip of lung tissue, the sounds at another place will be found to be distinctly louder when the tissue is taut than when it is relaxed. Some idea of the increased elasticity of normally distended lung tissue, as compared with the elasticity of relaxed lung tissue, can be gathered from the increase in size of the distended as compared to the relaxed lung. What actual resultant effect this tension has on the conduction of sound through the inflated lung we can only surmise.

With regard, then, to all these normal and pathological tissues just considered, the available evidence indicates that they are good conductors of sound, and that they do not differ greatly in their conductivity the one from the other, making some exception for distended lung tissue surrounded by air. The second point to be established is that the resulting effect on sound intensity is not materially different whether we are dealing with a single one of these substances, or whether the sound has to pass through a number of them, the distance to be traversed in the two cases being the same. That there is no material difference in the two cases the evidence indicates. The results are approximately the same whether one listens through two inches of gelatin, or through one inch of gelatin and one inch of liver. Sounds of moderate intensity introduced into the interior of the trachea of a fetal calf have been plainly heard through an inch of gelatin overlying the chest-wall. Whispering pectoriloquy has been heard through nearly two inches of gelatin overlying a patient's chest containing consolidated lung.

Thirdly, and finally, we find evidence that the various tissues act as though belonging to a single medium in their behavior toward other media, as might be expected from the fact that all are of about the same specific gravity (and elasticity). Thus, about the same loss of sound intensity is sustained as it passes to air irrespective of which kind of tissue the sound is coming from, and similar results occur if the sound passes in the reverse direction. Gelatin, fetal lung, muscle, and liver transfer sounds about alike to water, and the same rule holds good if sound travels in the reverse direction.

Our contention, then, that the soft tissues, normal and pathological, with some exception being made in the case of distended lung tissue surrounded by air, belong to practically a single medium acoustically, are sustained on all three counts, namely, that the different tissues are good sound conductors, and approximately equally so, that they behave in combination with one another much as though only a single one of them had been used, and, thirdly, that they behave practically alike in their relation to other media, as far as the reflection of sound is concerned.

Different Media in Combination.—Granting that the various "solid" substances, that is, normal and pathological tissue and gelatin, above considered, may all be regarded as one medium, and omitting from discussion for the present the membranous tissue of the lung, both in a relaxed and distended state, we have to consider, under combined media, media composed of just three simple media—air, water, and the substances composed largely of gel, the tissues, including the so-called "solids." The passage of a sound from air to "solid" is attended with a great loss of sound intensity, as might be expected when the sound has to pass between two such different media. This effect is demonstrated in those cases of pneumothorax in which the vocal resonance is abolished over the chest. If one fills the pleural cavity of a fetal calf with air and listens over the chest, the sounds introduced into the trachea are not heard or are very weak, though the sounds within the pleural cavity are very distinct. (Note limitations of stethoscope in this test.) The loss of sound in the reverse direction, from "solid" to air, that is, from a more dense to a less dense medium, is just as marked, though tests with the stethoscope might suggest that less sound is lost in going from a heavy to a light medium than in the reverse direction. Comparatively little sound is lost in the passage from tissue to fluid, or from fluid to tissue, their densities being nearly alike (and their elasticities?).

Factors Involved in Sound Transmission in the Normal Lung in the Normally Distended State and in the Relaxed State.—As we are able to describe the intensity of sounds only in relative and not in absolute terms, and because the investigation of the relaxed lung throws much light on the conditions present in the distended lung, the two will be considered together.

Comparison of Normal Lung Relaxed and in a State of Normal Tension.—So complicated are the lungs in regard to their behavior toward sounds passing through them, that it is very difficult to analyze the effects of the component parts on sounds. We can test the intensity of the sound at the surface, and we can demonstrate some of the factors responsible for the loss of sound, but it is difficult to give different factors their proper proportion, and there may be factors at work that are entirely unknown.

It is strange how generally it has been overlooked that the lung in its relaxed state, such as occurs when the lung is removed from the body, or when fluid or air appear in the pleural cavity, has an entirely different effect on sound vibrations from the normally distended lung, such as occurs in the normal living subject. Nearly all recorded comparisons between the sound conductivity of normal and solid lungs outside the body refer to relaxed and not to distended lung. Bullar is perhaps the only one who has drawn attention to this very important difference.

It is very easy to demonstrate that relaxed lung is a relatively good transmitter of sound, though not nearly as good as air. Very slight sounds introduced into the trachea of such a relaxed lung can be plainly heard at its surface, this being particularly true when one blows or whispers into one of the horizontal limbs of a T-glass tube, the vertical limb of which is connected with the interior of the trachea. The relaxed lung also is a distinctly better transmitter of air-borne tuning-fork vibrations than is the distended lung. The stethoscope is a more accurate instrument for determining the relative conductivities of relaxed and distended lung than it is for comparing the relative conductivities of these lungs and solid lung.

The difference in conductivity of the normally distended and the relaxed lung has been demonstrated by Bullar in a way that has never been surpassed, though it is not readily available. He constructed what he called an artificial thorax, the name revealing the principles involved. To represent the pleural cavity he constructed a compartment into which the lungs were introduced, the trachea projecting externally and communicating through its opening with the external air. The compartment itself, after receiving the lungs, was separated from all communication with the external air. At one portion this compartment was connected with an apparatus to work like bellows, by which air could be withdrawn from the compartment so as to secure negative pressure within it, the apparatus thus corresponding to the chest-wall with its inspiratory movements. The tubes of a stethoscope passed into the compartment,—so arranged that they did not allow any air to enter the chamber,—the receiver being fixed to the surface of the lungs. By withdrawing air by means of the bellows attachment from the compartment around the lungs, or by letting air into it, the lungs could be brought to any desired degree of tension or relaxation. The sound having been introduced into the trachea, the comparative effects of relaxed lung and lung in various degrees of distention could be studied.

Bullar, though primarily investigating the origin of respiratory sounds, showed clearly and definitely one very important fact regarding conduction, that the distended lung was a much poorer conductor of sound than the relaxed lung, this being revealed by the artificial thorax. He attributed the weaker sounds on the healthy side as compared to those on the side the seat of consolidation in cases of pneumonia to "the feeble conducting power of distended lung." He did not explain why the distended lung was a poorer conductor than relaxed lung.

An increase in sound over the surface of the chest can be demonstrated in a dead rabbit by a moderate degree of pressure on the chest-wall, thus producing some relaxation of the lung, the sound having been introduced into the trachea. The study of the distended lung is well carried on by allowing the lungs to remain in the body and removing a portion of the chest-wall over the lung, leaving only a thickness sufficient to keep the lung from collapsing. The intensity of sound found under these conditions can later be compared with the sound over the same lung when relaxed. A very distinctly louder sound will be obtained over the relaxed than the distended lung. The sounds introduced into the trachea in the cases studied were derived from the tuning-fork or the T-glass tube, as previously described. The distended and relaxed lungs may also be studied outside the body. One end of a rubber tube is inserted into the trachea and so held there that no air can escape from the lung except through the interior of the tube. Into the opposite end of the rubber tube the vertical limb of a Y-glass tube is inserted, also fitting tightly. The free end of each oblique limb of the Y-glass tube is fitted tightly into a rubber tube. Grasping the free opening of one of these latter tubes in the mouth and into the other inserting the base of a tuning-fork, one can inflate the lungs to any desired degree of tension, while listening to the vibrations at the lung surface coming from the tuning-fork.

If one wishes to use a T-glass tube, blowing or whispering or speaking through the horizontal limbs, while the vertical limb is connected with one limb of a Y-tube, and replacing the tuning-fork in the experiment last cited, he can obtain his results if some delicate membranous structure, like rubber tissue or animal membrane, covers the lower end of the vertical limb of the T-glass tube, to prevent escape of air from the lung. In this experiment one person inflates the lung while a second person conveys the sounds into the T-glass tube. This interposed membrane reduces the sound intensity considerably, but it does so alike for distended and relaxed lung, except that in one case the membrane is more tense than in the other. Sounds passing through the lung from one surface to another are also distinctly more weakened by the distended lung than by the relaxed lung. All experiments demonstrate a very decidedly greater loss of sound after its having passed through distended lung than relaxed lung.

How shall the difference in intensity in the two cases be explained? The simple increase in the amount of air in the distended lung will not altogether account for the weaker sounds at its surface, because, bulk for bulk, louder sounds come through collapsed lung than through distended lung. Thus one can place in contact with the relaxed lung one or more relaxed lungs, and even after the total distance through which the vibrations have to pass in reaching the stethoscope is greater with the relaxed lung, the sound is louder than over the distended lung.

Apart from the increased amount of air in the distended lung, the one striking feature exhibited by it not present in the relaxed lung is:

The Tension of the Membranous Tissues of the Distended Lung.—As the relaxed lung becomes more and more inflated the delicate tensile tissues of the parenchyma, and of the bronchioles as well, are stretched more and more, until the degree of tension of the lung in the body is attained. Can this tension play any part in obstructing the sounds as they pass through the distended lung? Physics teaches that relaxed membranes, such as occur in a relaxed lung, offer relatively little resistance to the air-borne vibrations on account of the thinness and flexibility of the membranes, while tense membranes, such as occur under normal conditions, when the tissue is stretched and tense, act much more powerfully as reflectors of sound vibrations. This principle is illustrated by the two following examples:

1. By placing the base of a tuning-fork in one end of a rubber tube long enough so that at the other end all vibrations are air-borne, and fitting this other end over a piece of glass tubing, allowing a layer of thin rubber tissue or animal membrane to be inserted over the end of the glass tubing, and between it and the rubber tubing, and then listening over the far end—the free end—of the glass tubing, or over the free end of a rubber tube attached to the free end of the glass tube, one perceives that the sounds are distinctly weaker when the intervening rubber tissue is in a state of tension than when it is relaxed. This demonstrates that the sounds pass through such tense material less readily than through the same material when relaxed.

2. The second example is to show that the interference with the sound in the case of a tense membrane is due to actual reflection of the vibrations. Two metal cylindrical tubes of equal length and diameter are each covered at one end with thin rubber tissue, which is drawn tense in one case and left relaxed in the other, and the proper tuning-fork is selected which will give the loudest sound for each tube when placed over its open end (tuning-

forks of different pitch being required in each case, as the tube with the relaxed rubber tissue is practically longer than the one with the tense tissue). It will be found that the louder sound will be heard in the region of the tuning-fork held over the opening of the tube closed at the opposite end with tense rubber tissue.

Finding no other condition satisfactorily accounting for the greater difficulty with which sounds pass through distended lung as compared to relaxed lung, and finding in the former case numerous small tense membranes surrounded by air in the place of the relaxed membranes of relaxed lung similarly surrounded by air, and knowing that tense membranes obstruct sound to a greater extent than relaxed membranes because of their greater reflecting action on sound vibrations, the conclusion seems justifiable that the tenseness of the tissues in the lung normally distended, with their consequent reflective action on sound vibrations, is largely responsible for the difficulty with which such vibrations pass through the lung in a state of normal tension.

The Bronchial Walls in Relation to Sound Transmission.—In the case of the solid lung the passage of sounds from within the bronchi to the bronchial walls is opposed by a very marked reflective action on the part of the walls. This reflective action is decidedly less in the case of a normal lung, especially on the part of the smaller and thinner walled bronchi, and still less when the lung is relaxed. With the normal and relaxed lungs there is also some loss of sound as the vibrations pass from the bronchial walls to the air in the immediately surrounding vesicles, a loss that is relatively slight where the bronchi are thin, especially if they are at the same time relaxed. It is, therefore, no easy problem to determine the relative intensity of sounds just external to the bronchial walls, in the normal lung and the solid lung. Where the bronchi are especially thick, it is probable that just external to them the sounds are louder in the case of the solid lung, because the surrounding vesicles are free from air, while it is possible that where the bronchial walls are attenuated the sounds just external to them are louder in the case of the normal than of the solid lung, because of the much greater reflective action of the bronchial walls, reënforced by their surrounding solid tissue, than of the normal bronchial walls, where these are thin.

We can say, in a general way, then, in speaking of the normal lung in a distended state, that a number of factors are present calculated to effect considerable reduction in the intensity of sounds passing through it, and that a very decided reduction actually does occur, and that the weakness of the sounds over the normal chest is largely due to this passage through the normal lung in its natural state of tension.

Factors Favoring Sound Transmission Through the Normal Lung Distended.—When one has completed his investigation of the factors tending to reduce sounds as they pass through the lung, he may be somewhat surprised to meet with as loud sounds as he does hear at the lung surface. One favoring factor is that the bronchi penetrate deeply within the pulmonary parenchyma, bringing the sounds thus far with comparatively little loss of intensity from diffusion. Another favorable factor is the air in the lung, which, *per se*, is, of course, a very good conductor, though this feature of the air is largely offset by the factors associated with its environment. Another factor is due to the connection existing between some of the membranous tissues and the bronchi, so that not all the vibrations escaping from the bronchial walls, large and small, necessarily pass next into the air in the pulmonary parenchyma, but some of them continue without any acoustic "break" into other tissue, namely, these membranous structures. These membranes, moreover, are continuous with other similar tissues, so that not all the vibrations are passing from air to tense membrane, and in the reverse direction, but some are advancing by direct tissue conduction. In addition, these membranes are under considerably more tension than any other tissues, normal or pathologic, with which we have to do, so that their elasticity, and therefore their conductivity, is correspondingly increased over other similar relaxed tissues surrounded by air. Finally, the tense tissues, though tending to reflect vibrations coming from the air inclosed by them, are so thin that the reduction in sound they accomplish is much less than if their thickness were greater. The factor of resonance of the sounds within the bronchi, as an agent tending to favor sound transmission, is considered in other places. Apparently it is at times a very important factor in contributing toward the normal degree of intensity of the vocal resonance over the chest. It is possible, also, that the tense membranes of the lungs may favor the passage of sounds of a particular pitch.*

As compared to the distended lung the relaxed lung presents a number of distinctly more favorable factors for sound transmission. In the first place, it is smaller, so that less sound is lost by diffusion, though it is true that less sound actually enters it. In the second place, there are no tense tissues to obstruct the vibrations. As in the case of the distended lung, the membranous tissue is so attenuated that it offers relatively slight obstruction to the air-borne vibrations traversing the lung. Other minor factors of advantage for sound transmission also exist.

The Effect on Vibrations Due to Their Passage from Lung to Chest-wall.—A marked loss in intensity occurs as vibrations pass from the lung, whether distended or relaxed, to the chest-wall and to similar structures, like liver and gelatin. Thus, if one reduces the thickness of the chest-wall sufficiently he finds a distinctly greater increase in sound as he approaches close to the lung than can be attributed to the reduced diffusion of the overlying medium alone. If one listens over the external chest surface of a breathing rabbit, or to sounds introduced into the trachea of a dead rabbit, he will notice a much louder sound close to the lung surface (after removal of a portion of chest-wall that leaves only enough of the wall to sustain the lung in its distended position) than at the external chest surface, the difference being distinctly greater than is accounted for by the passage of the sound through the thin chest-wall itself. The same general result is obtained when one studies the changes in sound intensity as the vibrations pass from lung, distended or relaxed, to liver or gelatin. The conclusion, based on our investigations, has been that the weakness of the sounds over the normal chest is to be attributed in considerable measure to the loss sustained at the junction of the lung with the chest-wall.

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* Less sound is retained within the bronchi of normal than of solid lungs.

To explain this loss of intensity at this point one must first picture the condition of affairs where the lung and chest-wall come together. From the acoustic standpoint the chest-wall may be considered to begin where the air in the peripheral or marginal air-spaces and the septa between them come in contact with the overlying, or superficially placed, lung tissue, which lies in contact with the pleura, which in turn is in contact with the chest-wall proper. There being no space between the visceral and parietal pleura except such as is occupied by a minute amount of lubricating fluid, the two layers of the pleura, as well as the immediately subjacent pulmonary tissue (not air), may be considered physically as part of the chest-wall.

The loss of intensity due to the passage of vibrations from the lung to the chest-wall may then be sought in the conditions affecting sound transmission from the most superficial (marginal, peripheral) air-spaces, and the septa between them, to the overlying tissue, that is, practically to the chest-wall. These two media, then, the air within the spaces and the tense membranes dividing the air into the spaces, carry all the vibrations to the chest-wall. One would naturally expect the air, which greatly exceeds the septal tissue in bulk, to contain most of the vibrations just prior to their entrance into the chest-wall. This view seems entirely reasonable, and, if it is, one can readily understand that much of the sound intensity could be lost in the "break" that occurs as the vibrations pass from air, a very light medium, to chest-wall, a medium many times heavier, a loss that, under all ordinary circumstances, is well known to occur, and is due to the reflection of the sound. This explains, we believe, the loss in intensity in sound as it passes from the lung to the chest-wall, an important and simple feature, but one hitherto apparently entirely overlooked. That the "break" is not more complete between the lung and chest-wall; that we do not encounter a loss comparable to that of pneumothorax, is partly due to the fact that, after the sound once reaches an air-space immediately beneath the chest-wall, there is not much opportunity for the sound to become diffused by the time it actually reaches the chest-wall, quite a different state of affairs from that ordinarily occurring with pneumothorax.

The Limitations of the Stethoscope in Testing the Loss in Intensity Due to the Passage of Sounds from Lung to Tissue.—If one listens with a binaural stethoscope over a lung, which may be either relaxed or distended, and which emits sounds of a given intensity, and then listens over a layer of tissue interposed between the lung and the stethoscope, the additional loss encountered in the latter case is not only due to the change of media at the lung-tissue junction, but is in part due to the change of media at the tissue-stethoscope junction. This is because more sound is lost in passing from tissue to stethoscope than from lung to stethoscope. But allowing for the increased loss at the tissue-stethoscope junction, and for the factor of diffusion occasioned by the tissue, a marked degree of sound loss may be traced to the passage of sound from the lung to the tissue.

The Tense Membranous Tissue Beneath the Chest-wall.—We have no direct experiments to show how much sound passes by way of the tense membranous septa between the air-spaces just beneath the chest-wall to the chest-wall. They evidently carry some vibrations, and, being in a state of considerable tension, are better conductors than if they were relaxed. But that they occupy so little of the total area immediately beneath the chest-wall suggests, though by no means proves, that they are only a minor factor in preserving the amount of sound heard at the external chest surface. It is possible that they offset to some extent the loss sustained by those vibrations that enter the chest-wall from the underlying air. That tissue mingled with air can play a more important part than air alone in sound transmission under certain circumstances we have been able to demonstrate by a number of experiments. Thus, it has been shown that sounds coming from a relaxed lung within a closed space separated from overlying tissue, in one case by air, and in the other case by relaxed lung, are distinctly louder at the external surface of the tissue when the relaxed lung than when the air intervened.

It will be seen, then, that it is a difficult matter to determine how much of the sound we hear over the normal chest comes from the air immediately beneath the chest-wall, and how much from the septa forming the walls of the air-spaces. What sound we cannot attribute to the air must travel by way of the membranous septa, and it is possible that they are as important a factor as the air itself in the transmission of those vibrations that gain entrance into the chest-wall.

In the case of the relaxed lung underlying chest-wall, such as occurs at times in pleural effusion, the tissue conduction from lung to chest-wall probably also plays a very important part, the amount of tissue beneath the chest-wall as compared to the air it incloses being greater than in the case of distended lung.

The Chest-wall.—The final medium through which the sounds have to pass to reach the exterior of the chest is the chest-wall. By itself it does not specially concern us, as we have to deal with it in practically all clinical conditions, normal and pathological. We have already determined that, as a medium for sound conduction, it closely resembles other soft body tissues. The effect of a thick chest-wall in reducing sound in comparison to a thin one is the result chiefly of diffusion.

Summary.—To summarize our conclusions thus far regarding the main loss in intensity of sounds as they pass through the normal chest from the interior of the trachea, we may mention—First, the loss due to diffusion, a loss to a considerable extent offset by the deep penetration of the bronchi into the pulmonary substance. Second, an important one, the loss due to reflection as the vibrations pass from the air in the tubes to the tube-walls. Third, a negligible one, the loss due to absorption as the sounds pass through the tube-walls. Fourth, an uncertain one, the loss due to reflection as the sound passes from the tubal walls to the surrounding air in the air-spaces. Fifth, the very important loss sustained by the passage of the vibrations through the normal lung in a distended state, which seems largely the result of reflection as the sounds within the air-spaces pass to their tense enveloping walls. Sixth, another very important loss, and also due to reflection, suffered as the vibrations pass from the air in the air-spaces immediately beneath the inner chest surface to the chest-wall. Seventh, the final loss due to diffusion as the sounds traverse the chest-wall.

It will thus be seen that the main special losses sustained in the case with the normal lung as compared to the case with the consolidated lung are, first, the loss as the vibrations in the bronchial walls pass to the surrounding air in the air-spaces; second, the loss effected by the reflective action of the tense septal tissue of the lung, and, finally, the loss due to reflection as the vibrations pass from the air in the lung to the chest-wall.

THE NORMAL THORACIC WHISPERED SOUNDS (NORMAL BRONCHIAL WHISPER, FLINT).

Flint, who was the first one to give decided impetus to the use of whispered sounds for clinical purposes, adopted for the description of the normal thoracic whispered sounds the term "normal bronchial whisper." He says, "the pertinency of this name is derived from the fact that the conduction of the sound produced by the whispered voice must be chiefly by the air contained in the bronchial tubes." He describes this sound as "a feeble, low-pitched, blowing sound, these characters corresponding to those of the expiratory sound in forced breathing." He also states that the whispered sounds are generally more intense than those which accompany even forced breathing, though there are exceptions to the rule.

The normal whispered sounds, though presenting almost no resemblance to the sounds heard over the trachea, evidently have the same source as the tracheal whispered sounds. If, instead, they arise in the lower respiratory tract and are simply a pulmonary expiratory sound, then they should be as much weaker than the pulmonary expiratory murmur as there is difference in the amount of air being expired in the two kinds of acts. But this is not the case. This subject is dealt with further in treating of the source of the normal expiratory thoracic murmur.

It is interesting to note how different the whispered sounds over the normal chest may be from those over the trachea, thus behaving in a general way like the spoken voice sounds in the two regions, the differences not being limited to marked changes in intensity alone, but also affecting the pitch and quality to a considerable degree. A lowering of the pitch and a muffling of the sounds are strikingly evident in both the whispered and spoken sounds, and apparently much the same factors operate to effect these changes in the two cases.

THE VOCAL RESONANCE OVER CONSOLIDATION OF THE LUNG. INCREASED VOCAL RESONANCE.

We have expressed our belief that the increased vocal resonance in cases presenting consolidation of the lung is not necessarily due to any increase in sounds within the bronchi, but to less unfavorable conditions for sound transmission outside the bronchi, as compared to the normal case. In the case of consolidation the vibrations pass from bronchial wall to consolidated lung tissue, and from the latter to chest-wall, without suffering any "break," as in the normal case, for the bronchial wall and consolidated lung tissue and chest-wall are sufficiently alike acoustically to be considered as belonging to the same medium, as previously explained.

While the above conclusion is arrived at sufficiently easily, it is a more difficult matter to determine experimentally the relative importance of the different factors occasioning the greater reduction in sound intensity over the normal than over the consolidated lung. The two main elements, as we have seen in reducing the sound over the normal lung as compared to the solid lung, are the poor transmitting qualities of the normal lung, and the loss of sound intensity due to the passage of vibrations from the air in the lung to the chest-wall. The more importance we attach to one of these elements, the less must we attribute to the other, and vice versâ.

Comparison of the Conductivity of Solid Lung and Normal Lung as Tested at the Surface, the Sounds Being Introduced into the Bronchi.—The solution of this problem would help to determine how much sound is lost at the normal lung-chest junction. That the normal lung normally distended, bulk for bulk, transmits sounds from within the bronchi to the surface of the lung, or through and through the lung from one surface to the other, decidedly more weakly than is the case with relaxed lung, is supported by all our experimentation, but to tell, from experimentation applied to the lungs themselves, whether the consolidated lung offers the louder sounds at its surface than the distended or relaxed lung, is not as easy of determination as might at first sight appear. To infer that solid lung should transmit sounds better than normal lung because we obtain louder sounds at the outer surface of the chest-wall when there is solid lung beneath than when there is normal lung, does not demonstrate what may be actually taking place at the surfaces of the two lungs beneath the inner surface of the chest-wall.

In trying to make careful comparisons of the two lungs, the normal and solid, there are a number of factors that may affect the results. Mention has already been made of the partial collapse that may occur in the solid lung after removal from the body, and of the presence of secretions and air in the bronchi after death, even when the lungs are still in the body. Again, results may be somewhat modified according to whether one tests vibrations going directly through the lung, or whether they pass first into the bronchi. Finally, the sounds at the surface of the normal lung normally distended inside the chest must be louder than if the normally distended lung is outside the body, for the same reason that the sounds are louder over the surface of a relaxed lung under water than outside, that is, because the sounds escape from the lung surface less readily when surrounded by solid or water than if by air.

What we are particularly anxious to learn, however, is this: what is the relative intensity at the external surface of the two kinds of lungs while they are still in the body and covered by the chest-wall? for then we can determine how much loss of sound in the case of the normal lung is due to the "break" occurring between it and the overlying solid parts. The ideal experiment,—one, however, that would have to be safeguarded by a number of precautions, and one which we regret that we cannot report,—would be to listen over normal and solid lung in the same living animal, with a button of tissue removed over each lung to allow the stethoscope to come as close to the lung as possible, and yet without penetration of the pleural cavity. With lungs outside the body we have also fared badly, because too much bronchial obstruction was encountered to allow of accurate results regarding sounds introduced into the bronchi. Most of the work has been carried on with liver or gelatin or some other substance fairly closely allied to solid lung. If the vertical limb of a T-glass tube is placed with the lower opening tight against the surface of distended lung or liver, the sound made by blowing through the horizontal limbs of the T-glass tube will usually be found somewhat louder over the opposite surface of the normal distended lung than over that of the solid liver (bulk for bulk).* If sounds are introduced into a trachea of a sheep and the bronchi tightly ligated, and first distended lung and then liver placed over or surrounding the trachea, rather louder sounds will be heard over the distended lung than over the liver. Sounds coming through distended lung overlying the living human trachea are a little louder than if liver of the same thickness is used. If sounds are introduced into the trachea of a fetal calf, the sounds heard over a distended lung placed over the fetal lung will be louder than over a piece of liver of similar thickness, taking the place of the distended lung. Much the same results are obtained if gelatin is used instead of liver. On the other hand, sounds over the chest-wall of a fetal calf are considerably louder than over the surface of one of the same fetal calf's lungs in a state of distention with air, but in the latter case the total thickness of the distended lung is greater than the thickness of undistended fetal lung plus the overlying chest.

As far as experiments like the above lead us, it might seem likely that there is not a great deal of difference between the conducting powers of distended and solid lung, the evidence, however, favoring the distended lung. As said before, the sounds are louder at the surface of the normal lung while still in the body and surrounded by the chest-wall, than over the distended lung apart from the chest-wall.

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* These sounds enter the lung more readily than the liver.

Limitations of the Stethoscope for Testing the Relative Conductivities of Solid and Air-bearing Lungs.—However carefully such experiments as those just cited may be carried on, the interpretation of the results is beset with difficulties, because the binaural stethoscope does not furnish an accurate estimate of the relative conductivity of objects of different density. Thus if we determine that sounds of nearly equal intensity are heard through the stethoscope applied directly to the pulmonary surface of distended and of solid lung, we should still need to know the relative amounts of sound passing from each kind of lung to the air in the stethoscope before we could establish the relative conductivity of the two kinds of lungs. With the marked differences in density between solid tissue and air, we assume that a profound loss of sound is sustained in its passage from such tissue to the stethoscope. In the case of the distended normal lung, however, the loss is apparently much less, as the air element in the lung tends to reduce the amount of loss in sound as it passes from lung to stethoscope.

If, then, nearly equal sounds coming from distended and from solid lung are obtained with the stethoscope, it appears reasonable to conclude that the actual intensity of sounds just before leaving the pulmonary surface is much greater in the case of the solid than of the distended lung, and therefore that the solid lung transmits sounds introduced intrabronchially, better than does the normal lung in a state of normal tension. This is borne out by whatever collateral evidence we have furnished pointing to the good conductivity of solid tissue.

The Relative Conductivity of Solid and Relaxed Lung.—In comparing the relative conductivity of relaxed and solid lungs, we are again met with difficulties in applying tests directly to the lungs. Although very loud sounds come through the collapsed lung to the stethoscope, louder than through the solid lung to the stethoscope, there is much less loss in sound in the passage from relaxed lung to stethoscope, than from solid lung to stethoscope. Summing up all our evidence, experimental and inferential, we are led to believe that the solid lung is a better conductor of sound than the relaxed lung, at least external to the bronchi.

Summary.—The reasons for the occurrence of weaker sounds over the normal chest than over the chest where there is consolidation are to be sought not only in the favorable conditions on the abnormal side, but also in the unfavorable conditions for sound transmission on the normal side. The specially unfavorable features on the normal side that are not present on the abnormal side are, first, the loss sustained as the sound passes from bronchial wall to air in the vesicles; secondly, the reflection backward of the air-borne vibrations in the lung as they strike the tense, membranous tissues surrounding the small air-spaces of the lung, and, thirdly, the marked "break" that occurs as the air-borne vibrations in the lung strike against the solid chest-wall. When the chest contains solid lung, on the other hand, we have the solid lung and the muscle of the chest-wall, that is, practically only one single medium to deal with,—after the vibrations enter the bronchial walls,—and this medium is itself a good conductor of sound. These seem to be the main factors in accounting for the differences on the two sides, and in explaining why the side with the large amount of air possesses the weaker sounds, and the side with the preponderance of "solid" tissue possesses the louder sounds, at the periphery of the chest.*

Our conclusions apply to various forms of uncomplicated consolidation, hepatization, caseation, fibroid disease, malignant disease, provided the bronchi remain patulous and come equally near the chest-wall.

The farther the consolidation extends centrally from the chest-wall, provided the bronchi extend a normal distance toward the chest-wall, the louder should be the sounds obtained, because more sound is in this way derived from the larger bronchi.

The factors of resonance and interference at work within the bronchi of the solid lung are considered in other places.

Diminished Vocal Resonance in Consolidation.—It is important to bear in mind that the vocal resonance may be diminished in uncomplicated cases of consolidation. This is a phenomenon that can sometimes be readily explained by bronchial obstruction, which may be a temporary condition due to the presence of secretion in the bronchi, or may exist permanently as a result of malignant disease involving the interior of the bronchi. In other cases diminished vocal resonance in consolidation, irrespective of the particular kind of consolidation, does not lend itself so readily to explanation. This is particularly true when associated with the diminished vocal resonance there are actual whispered pectoriloquy and bronchial breathing. This phenomenon demonstrates that the relative effects on the intensities of the spoken and whispered sounds may be quite different in normal and pathological conditions. We can only offer in explanation of this seemingly contradictory combination of physical findings that factors of resonance or interference come into play that relatively favor or impede the transmission of either the spoken or whispered sounds. This subject will be referred to again, and more particularly under Pleural Effusion, where the phenomenon of diminished vocal resonance in association with distant whispered sounds is more frequently observed. In speaking of pleural effusion the difference in length of the bronchi on the normal and affected sides is suggested as a possible basis for diminished vocal resonance in the presence of whispering pectoriloquy. In the case of consolidation the bronchi may be shorter as a result of the presence of contained exudate.

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* More sound is lost through reflection as sounds pass from within the bronchi to their walls in solid than in normal lungs.

Diminished Vocal Resonance in Fibroid Disease of the Lung.—Sometimes, though rarely, the vocal resonance is so markedly decreased in cases of fibroid disease as to merit special consideration. Sir Andrew Clark, whose opinion on the subject is generally held, attributed such a decrease to the presence of fluid in the pleural cavity, or to a thickened pleura. But if a thickened pleura acts in this way, why does it not do so oftener in cases of fibroid lung, as these cases are usually associated with thickening of the pleura? Sir Andrew Clark himself gives the details of a case exhibiting an increase in the vocal resonance, in which the thickness of the pleura varied from one-third to one inch. The fibroid pleura and the fibroid lung are the same structurally, and the fibroid pleura and chest-wall are much alike as to their effect on sound transmission. If the thickened pleura exerts any special influence in reducing the sound intensity, it is not because it is a worse conductor than other forms of tissue with which we have to deal, nor because it introduces the factor of a new medium.

The two factors that specially suggest themselves as offering an explanation for the diminished or absent vocal resonance sometimes encountered in fibroid disease are associated in the one case with conditions outside the bronchi, but not particularly affecting them, and in the other case with conditions strictly affecting the bronchi. The first factor would seem to be operative in those cases in which there might be conditions present between the bronchi and the pleura unfavorable to sound transmission, such as heavy strands of fibrous tissue alternating with air-bearing lung, or small cavities with walls of fibrous tissue. More potent factors, however, for sound reduction would seem to occur in whatever tends to remove the bronchi further from the chest-wall, which to some extent is accomplished by thickening of the pleura, and by whatever obliterates the bronchi peripherally, making them shorter, removing them farther from the chest-wall, and by factors reducing their caliber. In these ways the sounds would have to travel farther from the bronchi to reach the chest-wall, thus losing in energy as a result of diffusion. In the cases where the lumen is narrowed there would be fewer vibrations entering the bronchi, while there would be a relative increase in the area of sound-reflecting bronchial wall compared to their air contents.

PLEURAL EFFUSION WITH DIMINISHED OR ABSENT VOCAL RESONANCE.

It seems especially surprising that so familiar and apparently so simple a phenomenon as the decreased or absent vocal resonance in cases of pleural effusion should still go begging for want of a satisfactory explanation as to its mechanism. The best explanations we have been able to find are very incomplete, and some of the poorer ones would be admirably adapted to a comic section. Austin Flint (A. Flint: "Physical Explor.," 1856, p. 262), speaking of pleuritis, hydrothorax, and pneumohydrothorax, says: "The presence of liquid in the two former affections, and of air together with liquid in the one last mentioned, removes the lung so far from the thoracic wall that the vocal vibrations emanating from the larynx fail to reach the ear of the auscultator, or, if appreciated, are feeble and distant." Gee offers this explanation: "Pleural effusion brings in a new element of heterogeneity. The sonorous columns of air in the bronchi have to give up their vibrations to the condensed lung, which yields them in turn to the fluid contained in the pleural sac; from the effusion they have to pass through the solid walls of the chest." Apart from the very general and non-specific character of these explanations, we would direct attention especially to two common errors—first, that the mere distance of two objects from each other need not necessarily effect much reduction in sound, provided the media are good conductors, like air and water, if other conditions are favorable, and, secondly, that even the alternation of media of very different physical characteristics in other respects, if they closely approximate each other in density or specific gravity and elasticity, for example, fluid and tissue, may not cause much reduction in sound. "Diffusion and weakening of vibrations passing from one medium to another," as expressed by Wilson (J. C. Wilson, "Physical Diagnosis," 1911), covers the subject as well as can be done in so few words. Laennec, Skoda, Walshe, Wilson Fox, Samuel West, Sahli, Osler, Holt, and Cabot give no satisfactory explanation, as far as we can find, for the occurrence of diminished or absent vocal fremitus in pleural effusion.

The Degree of Diminution of Vocal Resonance in Pleural Effusion.—It is desirable to have some definite knowledge about the degree of diminution of the vocal resonance in cases of pleural effusion. While the resonance is generally described as being "absent" or "suppressed,"—and we suppose the latter is intended to signify the former,—our experience, particularly carefully recorded since we have been specially interested in the subject, supports Walshe's stand in the matter, that suppressed vocal resonance is a rare condition in pleural effusion, even over most of the chest below the upper limits of the fluid, and not referring to those regions in the neighborhood of the compressed lung. One is impressed not only with the frequency with which sound is preserved over the effusion, but also with the actual degree of intensity that often remains, even in large effusions. Our attention to this subject was particularly directed by the corresponding results obtained in experimental work, conducted with animal lungs, both inside and outside the body. In the case of a calf recently killed, sounds over a large artificial effusion (water), though materially reduced as compared to those on the opposite side, were still very distinct. In this case the vertical limb of a T-glass tube was connected with the interior of the trachea by rubber tubing, while an assistant spoke into the end of the horizontal portion of the glass tube.

The two main factors responsible for the diminution of the vocal resonance in pleural effusion are the factors of diffusion and of reflection, the latter in this case being due to a change of media from a very light one, the air in the lung, to a heavy one, the surrounding fluid. The former presents the only distinctive feature, as contrasted to the normal chest.

The points demanding investigation for the clearing up of the problem are, *first*, the intensity of the sounds at the lung surface; *second*, their intensity after having entered the fluid; *third*, their intensity just beneath the chest-wall; *fourth*, after having entered the chest-wall; and *fifth*, at the external chest surface, with, as near as possible, a knowledge of the factors favorable and unfavorable to the transmission of the sounds.

The picture of a developing pleural effusion where there are no adhesions shows an accumulation of fluid in the dependent portions of the pleural cavity, compressing the lung from below, and later, to a less extent, laterally, allowing gradually the relaxing lung to come in contact with the chest-wall immediately above the effusion, the fluid finally increasing in amount until the lung may be almost entirely separated by the fluid from the chest-wall.

We are particularly interested, first of all, in this relaxed portion of lung that comes in contact with the fluid, and will not at present speak of the compressed, airless, fetal type of lung sometimes encountered in cases of pleural effusion.

Enough has elsewhere been said to show that the sounds reach the surface of a relaxed lung with a much greater degree of intensity than in the case of a normally distended lung. Every one is familiar with the increase in vocal resonance frequently obtained just above an effusion, the increase being due to the relaxed lung in this situation. The reasons for the loud sounds at the surface of such a lung have already been presented.

While, however, in a case of effusion the intensity of sounds at the surface of a relaxed lung is greater than at the surface of a normal lung, the total quantity of sound actually within the lung is less than in the normal lung, because the tubal structure, having become shortened along with the relaxation or compression of the lung, less sound actually exists in the relaxed lung than in the normal one. The conditions are paralleled by using two rubber tubes of different lengths closed at their lower ends, the upper ends being attached to the two upper limbs of a Y-glass tube, the vertical limb being connected with a rubber tube which grasps at its other end the vertical limb of a T-glass tube. If the two rubber tubes first mentioned are each in turn immersed their full length in water, while sounds are introduced into the T-glass tube, more sound will escape from the longer tube. If this difference in total sound quantity in the relaxed and normal lung did not exist, the sound over the chest in cases of pleural effusion would be decidedly greater than it is. Adhesions preventing collapse of the lung would prevent some of this loss in total sound quantity. This phase of the subject, however, does not interest us as much as the actual intensity of the sound after having reached the lung surface.

The next step is to determine how the vibrations are affected by their transference into the fluid. One would expect to find a very decided decrease in the sound intensity as a result of the reflection of sounds from the air in the lung by the fluid, which is so much denser than air, the fluid having nearly the same specific gravity as tissue. This is just what occurs in all experimental work, an example of which is as follows: A suitable vessel is employed, opened only above, except for a small opening in or near the bottom of sufficient size to admit a tightly fitting rubber tube. One end of the tube is passed into the bronchus of a portion of lung and held there firmly, and closely approximated to the bronchial wall. The other end of the tube is then passed into the vessel from above and into the inferior opening, and then passed through it to the exterior, traction on the tube from outside the vessel being continued until the lung itself comes in contact with the vessel around the lower opening. It is essential for the lung and tube to have been so prepared that the fluid comes in contact only with the lung surface, and not with the bronchus or rubber tube, because sounds occurring within tubes of tissue or rubber, once they have entered the walls, readily escape into surrounding fluid—much more readily than from tube to lung, and thence into surrounding fluid. This occurs on account of the different degrees of reflection in the two cases, which depend on the differences in density of water and air, the tube or bronchus corresponding closely to that of tissue or rubber, and the relaxed lung parenchyma with its contained air being far lighter. Any exposure, then, of bronchus or tube to the fluid will allow the passage of sounds more intense than would be heard in the fluid after coming from the relaxed lung surface. In animal lungs a bronchus may be superficially situated for a sufficient length to give entirely erroneous conclusions as to what actually happens in the case of the relaxed lung. With, then, a portion of relaxed lung properly in place, the free open end of the rubber tube can be used for the introduction of sounds into the lung, and one may use any of the methods for this previously described, such as inserting the base of a tuning-fork into the tube, or the vertical limb of a T-glass tube, sounds being then introduced into the horizontal limb, either by the spoken voice or by simply blowing. The sounds heard at the surface of the relaxed lung within the vessel will be of the character described elsewhere for relaxed lung. If fluid is now placed in the vessel covering the lung, one may test the effect of the fluid on sounds coming from a relaxed lung. For the reception of sound one may use a binaural stethoscope in the ordinary way, the bell being placed against the surface of the liquid. Or one may use a bell covered with a membrane or with tissue, if this method was also employed in testing the sounds at the lung surface itself. Or, if one merely wishes to determine how the sound varies in different parts of the fluid, a rubber tube at the proper level in the fluid may be used to receive the sounds beneath the surface of the water, the lower opening of the tube being closed, the upper connected by means of a Y-glass tube with the rubber tubes of a stethoscope.

The results of such an experiment show a decided diminution in sound due to its passage from lung to fluid, as compared to the lung surface, even if the layer of fluid traversed is narrow, though a marked degree of sound remains. Presumably the intensity of sound in a case of pleural effusion just after the vibrations have entered the fluid approximates to some extent the intensity of the sound just after entering the chest-wall, at that point above the effusion where the vocal resonance is increased. If the lung is inflated instead of relaxed, the sound is much weaker, tested through the fluid, just as when tested at the lung surface. The relative results, comparing distended and relaxed lung, are much the same whether the lungs are separated from the stethoscope by fluid or tissue. The conditions favorable to sound conduction and sound reflection at the junction of either relaxed or distended lung and fluid are apparently very much the same as those at the junction of lung and tissue, and the loss in intensity is to be attributed chiefly to the reflection of sounds going from the air in the lung to the fluid.

The marked loss in intensity suffered by sound in its passage from air to water is readily shown. Thus if one partially fills a closed chamber, for example, of plasticine, with water, and introduces sounds into the space above directly through an open tube, or a tube having its lumen traversed at some point by a thin animal membrane, or if sounds emanate from the surface of a collapsed lung in the air-space, but not in contact with the fluid, all these sorts of vibrations will be very distinctly heard in the upper portion of the plasticine chamber, but beneath the fluid they will be found much diminished or altogether suppressed.

Again the question arises, how much can we tell about the amount of sound lost as it passes from lung to a denser medium, in this case to fluid, by the use of the stethoscope, which is an instrument that transmits sounds with less loss if they come from light media than from heavy ones? We can only refer to the remarks made elsewhere on this general subject, for they are equally applicable in the present instance, and to experiments which are detailed elsewhere, showing that much more sound is lost as it passes from relaxed lung than from solid lung to water, whether one applies the stethoscope directly to the fluid or interposes a layer of tissue.

One would not expect any special effect on sound to occur as a result of the air in the lung being separated by the delicate superficial pulmonary tissue from the fluid, because under the circumstances membrane and water offer about the same obstruction to sound as water alone. This supposition is supported by the following experiment: A bottle of ordinary shape is employed, except near the bottom a short, small caliber outlet is present. Through a perforation in the cork used for the larger opening a tightly fitting rubber tube is passed, one end, closed, passing some distance within the bottle, or the tube may even be curled upon itself inside the bottle, the other end, outside the bottle, being connected with the stethoscope. The bottle is filled with water right to the mouth of the small outlet, which is kept upright, the bottle being placed on its side. A second rubber tube is used, one end being placed over the end of the small outlet in the bottle, the other receiving the vertical limb of a T-glass tube, into one of the horizontal limbs of which sounds are introduced. The second rubber tube is divided into two parts by a thin membrane, designed to eliminate the relatively violent agitation of the fluid which would occur without it in the production of some sounds, and to simulate a little better the conditions in the lung. The sounds pass through this diaphragm membrane, enter the fluid in the small outlet portion of the bottle, reach the rubber tube within the bottle, and so gain access to the ear. If, now, one places across the mouth of the outlet from the bottle a thin layer of animal membrane not separated from the fluid in the outlet by air, but in contact with the fluid at all points, he will notice no diminution in sound intensity, the rest of the apparatus remaining as before. This indicates that sounds going from air to fluid give approximately the same results as from air to membrane to fluid, provided the conditions are such as occur in the lung.

The Importance of Diffusion in Reducing the Sounds.—The sounds having entered the fluid in the pleural cavity, which they do preserving at least as much intensity as though they had entered tissue, and are therefore as powerful as vibrations that enter the chest-wall from a relaxed lung overlying fluid, provided the degree of relaxation is the same in the two cases, continue through the fluid. The fluid, however, being such an excellent conductor of sound, does not, *per se*, reduce the intensity of the vibrations on their way to the chest-wall, that is, what loss occurs in this interval is not to be traced simply to the distance separating the lung from the chest-wall, or the imperfect conductivity of the fluid. What does reduce the sound intensity, however, is diffusion of the sounds, and not the poor conducting properties of the water. Diffusion of sound between the lung surface, free from adhesions, and the chest-wall, shares the honors with the reflection of sound from the fluid back into the air in the lung, in reducing the intensity of the sounds in their passage from lung to chest-wall in ordinary cases of pleural effusion.

This can be readily understood by comparing the relative areas of visceral pleural surface and parietal pleural surface in contact with the fluid at any stage in the development of the effusion. As long as the lung floats on top of the fluid we find only the inferior surface of the lung bathed by the fluid, whereas we have an anterior, posterior, two lateral, and an inferior non-pulmonary surface walling off the effusion. The diaphragm offers a very large pleural surface, the area being partly due to its upward convexity, while this convexity remains. The area of pulmonary surface compared to that of non-pulmonary surface in contact with the fluid will stand approximately or in a general way in an inverse ratio to the intensity of sound at any given point on these two surfaces. The reduction in sound will naturally become more marked as the fluid increases, but this tendency is offset to a certain extent by two factors. First, the more the lung becomes compressed, as long as the bronchi remain patulous, the greater are the sounds at its surface. Secondly, with increase in fluid relatively more of the pulmonary surface comes in contact with the fluid.

This state of affairs can be clearly shown by making use of the portion of lung in the vessel previously described. When a thin layer of fluid separates the relaxed lung from the stethoscope, a sound of a given intensity is audible. As the fluid increases the sound decreases, and with enough fluid can be very materially reduced. This is simply the result of diffusion, and not of distance or deficient conduction.

The principle of diffusion explains to a great extent why, in pleural effusion, the sounds over the fluid are diminished, while those above the fluid are increased, and yet both emanate from relaxed lung.

In much the same way in the normal subject the weakening of the voice sounds as one moves the stethoscope from the base of the lung in front down over the liver is to be attributed to diffusion.

The next step the vibrations take on their way to the periphery is across the boundary between the fluid and the chest-wall. As the fluid and the chest-wall possess a fairly similar density, one should expect the transference from one to the other to be effected without great loss in intensity, despite the fact that fluid and tissue are in so many physical and even acoustic respects far different from each other. Such a supposition is confirmed by experiment. Sounds may readily be introduced into water in a great many ways, for example, as with the lung just referred to, or by submerging under water a rubber tube closed at the lower end, the other end being used for the admission of sounds. One can then compare the intensity of the sounds at the surface of the water, first, with the bell of the stethoscope, and, secondly, with the bell separated from the fluid surface by a layer of tissue such as muscle or liver, when the sounds will be found to have preserved most of the intensity obtained with the bell alone. One may obtain much louder sounds from fluid with a larger surface for the reception of sounds, for instance, with a rubber tube under the water with its lower end closed, or with a submerged heart, the upper end of the tube or one of the vessels of the heart being connected with the rubber tubes of the stethoscope. The heart, of course, must contain no fluid.

Some vibration-energy is lost in the transference from fluid to chest-wall—just how much we cannot say, apparently a relatively inconsiderable amount.

The vibrations finally have to traverse the chest-wall, and as this occurs in all the clinical cases, nothing need be added to the subject here.

Our experiments would suggest that diminution in vocal resonance and not a total abolition of it would be the rule in cases of pleural effusion when the patient has a sufficiently strong voice. The complete single experiment to show this is the one first presented, of the portion of lung in the vessel, the voice sounds being introduced into the lung from outside the vessel. With a separation of the lung from the surface of the water by several inches, and with the upper water surface everywhere in contact with liver a half-inch or more in thickness, quite distinct sounds will be heard over the external surface of the liver.

The loss in intensity due to diffusion is considerably counterbalanced by the increase over the normal of the sounds at the pulmonary surface, which are very decidedly greater, if the lung is relaxed to the extent we find it on removal from the body. Apart from a weak voice or a thick chest-wall, requirements for a complete abolition of sound would seem to be either a lung markedly reduced in size to favor diffusion, or intrabronchial obstruction due to the presence of fluid, or fluid and air in the bronchi, quite uncertain factors. Compression of the bronchi from without is also a questionable factor in sound reduction, because the larger tubes are not readily compressed, and because much pressure maintained leads to atelectasis, which would tend to increase the sounds as finally heard. Our experiments incline us to believe that the sounds at the pulmonary surface gradually increase from the state of normal tension to that of complete relaxation, and later of atelectasis.

The chief reason, then, that the voice sounds are diminished or absent over a pleural effusion may be ordinarily attributed to the factor of diffusion.

PLEURAL EFFUSION WITH NORMAL OR INCREASED VOCAL RESONANCE.

Of the many complicated problems in the field of the mechanism of physical signs of the respiratory system, perhaps none has been so admittedly puzzling, particularly in adults, as that of the normal or increased vocal resonance sometimes encountered in cases of pleural effusion over, not above, the fluid. Skoda thought he had solved the riddle by attributing the phenomenon to what he calls consonance, but his explanation is untenable. Walshe expresses his idea of our knowledge of the subject in these words: "Sometimes explicable by solid adhesions conveying the vibrations from the lung to the chest-wall; in other instances the anomaly does not admit of explanation." How adhesions can favor the transmission of sounds to any great extent except by bringing the lung nearer the chest-wall we do not know. The statement that the pleural effusion if large enough can exert pressure upon the mediastinal membranes, rendering them tense and thereby making the conditions for sound transmission over the affected side better than over the normal side, cannot be supported.

Reports of this occurrence are more frequent in regard to children, but as to any exact figures, they are totally lacking. In adults, as far as we have been able to determine, the proportion of cases exhibiting increased vocal resonance, out of all cases of pleural effusion, is very small, and in the experience of some it is an extremely rare occurrence. In a good many cases where egophony and bronchial breathing have been reported, one might conclude that the vocal resonance was also increased, but an actual increase in intensity of voice sounds, and not merely a change in pitch or quality of the sounds, we believe to be the exception and not the rule in cases where bronchial breathing and some modification in the quality or pitch of the voice sounds occur. On the other hand, we believe that some cases of effusion with increased vocal resonance, or other signs suggesting consolidation, are not recognized, either because they have been mistaken for that condition from the start, or because the case, primarily one of consolidation, later becomes complicated with an effusion.

If we are justified in particularly attributing the diminution in sound after leaving the lung surface in cases of pleural effusion to two factors, diffusion and reflection (the latter operating where the relaxed lung comes in contact with the fluid), it is natural to look for relatively louder sounds under circumstances where these factors would exert less influence.

Diffusion would be restricted by whatever would tend to bring the lung surface nearer the chest-wall. In children it has been claimed by Barthez and Rilliet, and also Ziemssen (quoted by Wilson Fox), that the smaller size of the child's thorax does not allow a sufficient accumulation of fluid in the pleural cavity in proportion to the bulk of the lungs, so as to prevent vibrations reaching the chest surface, which means that the lung surface, compared to the inner chest surface, is not sufficiently reduced to allow as much diffusion as in the adult. Adhesions might keep the lung near the chest-wall, while still preserving as loud sounds at the pulmonary surface as in the case of a relaxed or solid lung, the increase in intensity at the pulmonary surface more than offsetting the diffusion of sound on its passage to the chest-wall. The difficulty of recognizing small loculated effusions and empyemas may, in some cases, be partly explained by the preservation of sounds in the manner described. With small animals our experience has been that in rabbits we have obtained louder sounds, introduced into the trachea, over an artificial effusion, than over the normal lung, but in one cat the usual finding of decreased sounds over an effusion was obtained, sustaining clinical experience that there is no rule about the vocal resonance even when the chest is small. But however much reduction in sound may occur as a result of diffusion in cases of pleural effusion, the fact remains that with large effusions and small compressed lungs the diffusion may not result in an ultimate reduction of sounds on the affected as compared to the normal side. And the diffusion is at least no greater when the effusion presents an increased instead of a decreased vocal resonance.

In those cases of increased vocal resonance which cannot be explained on the basis of a lessened diffusion as compared to the amount of diffusion in cases with diminished vocal resonance, our investigation must be pursued further. The attempt to explain increased or normal vocal resonance by an absence of, or partial elimination of, the second special factor held responsible for the diminished vocal resonance ordinarily met with in cases of pleural effusion, seems to meet with particularly encouraging results. This factor has been described as the loss of sound due to reflection of sound on its way from the air in the collapsed lung to the fluid. The first conditions of the lung to be investigated, then, are those in which the air in the parenchyma has disappeared—in other words, the conditions in which the lung becomes solid, either as a result of atelectasis or of inflammatory or malignant consolidation.

That increased sounds may occur when consolidation and fluid coexist is common knowledge, based largely, perhaps, on cases with the development of fluid in the pleural cavity where a pneumonia or some similar condition was known to exist previously, the fluid not preventing the persistence of increased sounds. Probably suspicion less frequently arises as to the possibility of a coexisting consolidation in cases with increased vocal resonance when fluid is demonstrated first. Having no case to report presenting before death a normal or increased vocal resonance, and at autopsy a solid lung separated from the chest-wall by fluid, we are obliged to resort to other means, which, however, we consider relatively satisfactory, for determining whether an airless lung would present the conditions favorable to an increase in vocal resonance over a pleural effusion.

Our most illuminating experiments along this line have been with the chests of fetal calves near term. In such animals the alveoli, being free from air, we are enabled to deal with one type of solid lung. Sounds introduced into the trachea of such an animal reach the external chest surface with great distinctness, the conditions apparently being more favorable for sound conduction than in cases of hepatization of the lung observed in human beings. If fluid is introduced into the pleural cavity of a fetal calf until it is completely filled, the sounds at the periphery of the chest will be found to have undergone comparatively little change, being still very distinct, while if the water in the pleural cavity is replaced by air, the sounds at the external chest surface will be found to have undergone a very marked diminution. If the fetal chest contains fluid and the lung is inflated, the sounds at the periphery of the chest will be found to be much weaker than while the lung was still air free.

An experiment comparable to the above, with similar results, can be performed with the fetal lung outside the body. If the fetal lung is submerged in a vessel containing water, and sounds are introduced into the trachea, and if a stethoscope is used, the mouth of the bell being tightly covered with a piece of liver to represent chest-wall, and if the opposite surface of this liver is likewise placed in contact with the water at and just beneath the surface, but at no point touching the lung, the sounds will be heard with great distinctness after having passed through fetal lung, water, and liver. Very much weaker sounds will be obtained if the fetal lung is replaced by an air-bearing lung.

Another experiment closely resembling the preceding ones can be made by replacing in the last experiment the fetal lung by a heart. Sounds, after entering the aorta and having passed through the cardiac walls, the fluid, and the liver covering the inferior opening of the stethoscope, still retain considerable intensity. Moreover, if one listens over a portion of collapsed lung from which louder sounds are coming, as detected by the stethoscope, than from the surface of a heart, and then separates each again from the stethoscope by fluid to such a distance that all sounds have disappeared coming from the lung, he will still obtain quite loud sounds emanating from the heart. With experiments of the same kind one finds that sounds go distinctly more loudly through heart, water, and liver than through relaxed lung, water, and liver. The sounds in these cases were introduced into the left ventricle of the heart, the walls of which averaged a good half-inch in thickness. We recognize the objection to the use of the bell of the stethoscope for receiving sounds from both relaxed lung and heart, the loss in sound intensity going from the air in the lung to the air in the stethoscope being less than from the muscle of the heart to the air. It is possible that the sounds are actually louder at the surface of the solid lung or heart than at the surface of the collapsed lung. But a consideration of all the experiments will demonstrate the correctness of the general conclusions.

One can readily become convinced of the facility with which sounds pass from solid tissue to fluid by applying a suitable cylinder to the neck or chest-wall, and inserting water into this cylinder so that it is in contact with the chest-wall, while the opposite end of the cylinder is tightly joined to the bell of the stethoscope. The vocal resonance and the respiratory murmur, though diminished, will be very distinctly audible. The same result may be obtained by listening to an individual with his chest under water, the stethoscope being near enough to the chest-wall to prevent too much loss from diffusion of the sounds.

Our experiments outside the body compare satisfactorily with conditions found in pleural effusion, as far as the fluid and the material between it and the stethoscope, representing chest-wall, are concerned, and are like those already described in connection with pleural effusion giving diminished vocal resonance. The conditions present clinically, as is well known, may be similar external to the lung for both kinds of cases—those with increased and those with diminished vocal resonance.

The experiments also represent fairly well, we believe, the conditions at the lung surface in the clinical cases. With the clinical cases possessing relaxed lungs we have compared relaxed lungs, with the cases having solid lungs we have compared airless tissue in the form of fetal lung (our best example), heart, and other forms of tissue, such as muscle and liver, all of these behaving practically alike, and presumably like the solid lung in the clinical case with increased vocal resonance. How closely the solid material of a pneumonic lung resembles tissue acoustically has been previously discussed.

When a pleural effusion exists, there may be associated either one of two types of solid lung—first, that in which there is no infiltrative process, but from which the air has disappeared as the result of pressure or absorption, leaving a lung closely resembling the fetal type, and, secondly, the lung which is solid as the result of inflammatory or malignant change. The airless but otherwise normal lung would, on account of its smaller bulk, probably offer more favorable opportunities for sound conduction as far as the lung surface than a hepatized lung, provided that in the two cases the bronchi were equally patulous.

It is possible, according to Skoda, for only a portion of a lung to become airless as a result of an effusion, and to sink beneath the surface of the fluid.

Our conclusion is, then, that the only difference that may exist between a case with a relaxed and a case with a solid lung in cases of pleural effusion, is the difference in intensity between the sounds immediately after they have entered the fluid from the lung, the sounds being decidedly greater when the lung is solid. This difference in intensity in the case of the airless and the air-bearing lung seems to us sufficient, as seen especially in the demonstration with the fetal lung before and after distention with air, to give in one clinical case a diminished vocal resonance, and in another increased vocal resonance, all the conditions in the two cases being identical, including the amount of effusion, and excepting only the nature of the two lungs. It is also possible that the solid lungs transmit sounds to their surface a little more loudly than the collapsed, air-bearing lungs. Of course, anything that would allow the solid lung to be nearer the chest-wall, such as a small amount of fluid, as occurs with adhesions, will, by the prevention of diffusion, favor still further the transmission of sounds in these cases.

A clinical case in point, reported by Calvert (W. J. Calvert: Jour. Amer. Med. Assoc., vol. xlix, p. 1921), may be referred to:

"*History of Case.*—In a young adult, white, male, with suspected left-sided pleurisy, examination revealed increased vocal fremitus and bronchial breathing throughout the left side. After withdrawing 1500 c.c. of fluid, an absence of vocal fremitus and bronchial breathing throughout the left side was noted. After several tappings practically all the fluid was removed. During this time vocal fremitus gradually returned, but was less than normal when the patient was discharged." In this case the change from increased to absent vocal fremitus can be explained only on the supposition that an atelectatic lung, existing originally, partially expanded and became air-bearing after the removal of the fluid, the sounds much more readily gaining admission to the fluid from the surface of the atelectatic lung than from that of the air-containing lung, and being actually louder at the surface of the compressed lung than that of the more expanded lung.

In a case seen at the Pennsylvania Hospital through the courtesy of Dr. George W. Norris, absent vocal fremitus, flatness, much diminished vocal resonance, and absence of the breath sounds existed over most of the right side of the chest. After withdrawal of 2800 c.c. of fluid the vocal fremitus and resonance became increased over the right side in front as far down as the fifth rib, while the dulness remained almost as complete as before and was associated with feeble bronchial breath sounds. Posteriorly, there was some, but less, alteration in the clinical manifestations. How can this change in the physical findings be explained except on the ground that the removal of the fluid favored the movement of an atelectatic or otherwise solid lung, if not into actual contact with the anterior chest-wall, at least so that it would be separated by only a narrow layer of fluid from the chest-wall, providing conditions not conducive to sound diffusion, the bronchi at the same time, perhaps, being relieved of a certain amount of pressure obstruction existing while the large effusion was present?

Our conception, then, of what we believe occurs in some cases of pleural effusion with a normal or increased vocal resonance may be summarized as follows: The sounds reach the surface of the solid lung with a certain degree of intensity, which is naturally greater than would be encountered at the external chest surface in a case of pneumonia without effusion, because the sound has not yet been diluted so much through diffusion. The intensity of sound at the lung surface will vary to some extent with the amount of lung tissue that is traversed, so that we would expect there to be louder sounds at the surface of a lung that is airless from compression than one that is solid from infiltration. The vibrations then enter the fluid, and do this without any serious "break" as a result of the change of medium. In their course through the fluid no appreciable sound is lost through absorption because of the excellent conducting properties of fluid, though the area of lung surface exposed to the fluid, compared to the area of thoracic wall in contact with the fluid, will govern to a great extent the amount of sound lost by the important means of diffusion. The total loss in intensity in cases of effusion due to diffusion, as a result of shortening of the bronchi through compression, as compared with the longer bronchi of normal lungs, we do not consider a very important factor. Finally, the vibrations enter the chest-wall, and again effect a transfer of medium without great loss of intensity. In other words, the interference in sound conduction is not greatly different, as a result of the fluid in the pleural cavity surrounding a solid lung, from a case presenting a solid lung without any effusion, apart from the differences due to diffusion, provided the bronchi remain patulous. It is certainly true that the conditions for sound transmission are much better in a case with a solid lung surrounded by fluid than in a case of effusion in which the lung still contains air, or in a case of pneumothorax, whether the lung in the latter case is either solid or air bearing, and provided there is no perforation from the lung into the pleural cavity.

If our explanation is correct, why does not this phenomenon occur oftener? As a matter of fact, it is impossible to state just how often a normal or increased vocal resonance does occur in cases of pleural effusion. Small basal accumulations of fluid overlying solid lung, giving a normal or increased vocal resonance, are probably not very rare. As to the actual causes for the infrequency of the phenomenon, they may be considered to lie chiefly in the lung substance or in the bronchi. We have already spoken of the marked loss of sound that occurs when a lung still retaining air in the parenchyma is in contact with fluid, and this we believe to be the common cause. Interference with sound transmission from bronchial obstruction might be caused either by pressure from without, thus bringing the bronchial walls in apposition, or by edema within the bronchi, which, through the action of fluid, or fluid and air, that is, froth, would occasion an intrabronchial obstruction to the passage of sounds. We question whether bronchial obstruction is an important factor in reducing the sounds on their way to the chest-wall.

Our conclusions regarding solid lung are offered in explanation of only some of the cases of pleural effusion manifesting a normal or increased vocal resonance, for we do not believe the explanation holds good in all cases, and especially in children we believe that other causes may operate. Some of these other factors have already been referred to. Less tangible but perhaps effective factors that may be responsible for increased vocal resonance, or a vocal resonance of greater intensity than that usually encountered in pleural effusion, are the factors of resonance and possibly of interference, arising as a result of the bronchi and their contained air.

The conclusions apply to various forms of fluid in the pleural cavity, whether serous, purulent, or hemorrhagic.

This subject has clinical as well as theoretical interest. Thus in any case of a doubtful nature presenting a normal or increased vocal resonance the idea of fluid in the pleural cavity should be entertained, and given a case with demonstrable fluid in the pleural cavity exhibiting clinically a normal or increased vocal resonance, the possibility of there being solid lung beyond the fluid should be borne in mind. While in some cases such a solid lung may be simply a compressed and airless lung, the other alternative is also to be considered, that the lung may be affected with inflammatory or malignant disease. If the condition is a recent one, recently developed consolidation of the lung is to be suspected.

WHISPERED PECTORILOQUY OR WHISPERED BRONCHOPHONY ASSOCIATED WITH DIMINISHED VOCAL RESONANCE.

One of the most striking and puzzling of the acoustic phenomena with which we are concerned is the association of whispered pectoriloquy or bronchophony with diminished vocal resonance, a combination with which we are most familiar in cases of pleural effusion, but which will be found oftener than expected in cases of consolidation, if carefully looked for. With the respiratory current distinctly less during speaking and whispering than during ordinary expiration, it is not likely that sounds of any importance are produced in the lower respiratory tract during speech or whispering, and therefore we may consider the spoken and whispered sounds to arise chiefly in the upper respiratory tract. The problem, then, is that of two sounds, which, after having traversed certain obstacles, are found, the one originally louder to be distinctly reduced in intensity, the weaker much reduced or absent, but which, under other circumstances, are found, the louder to have become more reduced in intensity than previously, and the weaker less reduced in intensity than previously. This state of affairs, in which the relative diminution of two sounds coming from a common source varies under different circumstances, or in which, as occurs clinically, whispering pectoriloquy or bronchophony is obtained when the vocal resonance is diminished, seems to us explicable only on the hypothesis that the sounds are differently affected by factors of either resonance or interference, or by both kinds of factors. We have also treated of this subject somewhat under normal vocal resonance, under diminished vocal resonance in consolidation, and under egophony, and have cited the only experiment we can offer that seems to throw much light on the subject. In this experiment we placed a thin disc of cork between the trachea and the stethoscope, and obtained a vocal resonance feebler than that over the chest, while the whispered sounds remained relatively intense. It appears that in this case the cork, though a poor transmitter of sound, still, being a sonorous body, was able, on account of its shape and size, to reënforce the sounds having the pitch of whispered sounds, whereas it simply acted as a conductor of the spoken sounds. The two sonorous bodies in the lower respiratory tract in cases of effusion that theoretically might reënforce the whispered sounds, without having any such effect on the spoken sounds, are the air in the bronchi, an explanation that appears more likely, and the relaxed lung surrounding the bronchi, which hypothesis seems less likely, and in our hands has not lent itself to demonstrable proof.

THE INTENSITY OF SOUNDS OVER EXCAVATION.

Increased Vocal Resonance over Cavities.—Increased vocal resonance over cavities ordinarily is to be explained much as the increased vocal resonance of consolidation,—by the presence of solid tissue between the walls of the cavity and the internal chest surface. At times the sounds may be louder within the cavity than within the bronchus, as a result of resonance.

Diminished vocal resonance, though not the rule, is quite frequently encountered over excavations. Exact statements as to its occurrence are hard to obtain. Walshe states that the vocal resonance in cases of excavation hopelessly varies. If normal lung tissue in a state of normal tension separates the cavity from the chest-wall, the sounds will be relatively reduced, just as they are when such tissue separates a bronchus from the chest-wall. Sometimes the diminished voice sounds are readily explicable by the presence of fluid or semifluid material within the cavity or its communications. Under other conditions we may have to resort to speculation to give any explanation in a given case presenting this finding. Factors of resonance and interference may be the cause of the diminished intensity of the sounds. External to the cavity the conditions may be those associated with diminished vocal resonance in other clinical affections, such as effusion, pneumothorax, and, rarely, fibroid disease of the lungs.

THE INTENSITY OF SOUNDS IN PNEUMOTHORAX.

From the standpoint of sound intensity, cases of pneumothorax may be classed either as those with the intensity of the vocal resonance diminished or absent, and those in which it is normal or increased. As in cases of effusion, the former is the usual state of affairs, and the latter finding is very infrequent. On a physical basis we may also make two divisions of the cases—one, that nearly always encountered, and the other observed only exceptionally, the distinction depending on whether or not there is an open fistulous tract allowing actual communication between the pneumothorax cavity and the interior of the bronchi. The acoustic factors responsible for the intensity of the sounds as heard over a pneumothorax are those to which we have already frequently resorted for an explanation of our clinical findings, though their application in pneumothorax presents some points of departure.

In those cases in which the voice sounds are diminished or absent it is important to know how the intensity of the sounds compares in pneumothorax and effusion, granting that the lung is equally compressed in the two cases, and that there are no other complications. From our own experience, and from the literature, we can offer no data to determine this point, though we are inclined to believe that the weaker sounds occur more often in pneumothorax, basing the belief more on a general clinical impression combined with theoretical considerations and experimental work than upon any definitely recorded experience.

If one pictures a chest on one side possessing a recently acquired pneumothorax, and on the other side a recently developed effusion compressing the lung to the size of its fellow on the opposite side, one has two conditions in which the feature of striking difference is found in the contents of the pleural cavity, air being present in one case and fluid in the other. The conditions for sound transmission through the lungs themselves in the two cases are, or may be, the same, and the conductivity of the chest-wall in the two cases is the same, and the opportunities for diffusion and conduction of sound between the lungs and the chest-wall may be considered as practically identical, as both air and fluid are excellent conductors of sounds, and the distances need not be great enough between the lungs and the chest-wall to reveal any differences in the two cases. Our chief regions of interest, then, are two—the junction of the pulmonary surface with the air or fluid in the pleural cavity, and the junction of the air or fluid in the pleural cavity with the chest-wall. It will be readily seen that one of the most potent factors in sound reduction in the two clinical conditions is the reflection of sound in its passage between a dense medium and air, this occurring with particular effect in pneumothorax, where the air comes in contact with the chest-wall, and in pleural effusion, where the lung comes in contact with the fluid. Now if the sound in pneumothorax were reduced in the same proportion at the air-chest-wall junction as in pleural effusion at the lung-fluid junction, and vice versâ, that is, in the same proportion at the lung-air junction in pneumothorax as at the fluid-chest-wall junction in effusion, the size of the collapsed lungs in both cases being identical, then the resultant sounds at the external chest surface would be the same. But, however near the truth such a computation might be, it is very difficult to determine by experiment just how much the relative reduction in sound is under these different circumstances.

If we compare the points of greatest sound loss in the two clinical conditions, we find that the loss is relatively greater in the case of pneumothorax where air alone comes in contact with the chest-wall than in the case of effusion where the vibrations entering the fluid come not only from air, but to some extent also from tissue, which transfers sounds to fluid with comparatively little loss. If we compare in the two clinical cases the regions of relatively slight loss in sound intensity, which in pneumothorax is at the lung-air junction, and in effusion at the fluid-chest-wall junction, we have a very difficult task, if our investigations are being carried on with the stethoscope, because in the former case sounds are coming from air into the same medium in the bell of the stethoscope, while in the latter case the sounds come from a dense medium—tissue—to a medium of very different density—air—in the stethoscope, considerations which have been dealt with in a general way previously. Accurate determinations of sound under these conditions are not necessary for our purpose, however, because the loss is not great in either case, certainly not enough to materially affect the final results. As far as our experiments go, the results are fairly similar in the two cases, that is, the loss in intensity from collapsed lung to air is not greatly different, relatively, from the loss sustained as the vibrations pass from fluid to chest-wall.

Granting that the relative loss in the two cases is approximately the same, there is only one important region remaining in each type of case (effusion or pneumothorax) to effect differences in sound intensity that may appear at the external chest surface in cases of effusion as compared to those of pneumothorax. In other words, we have to compare the loss of intensity suffered at the lung-fluid junction in effusion with the loss sustained at the air-chest-wall junction in pneumothorax. One can readily tell whether more sound is lost in passing from relaxed lung to fluid (as in effusion), or from air to tissue (as in pneumothorax), by the following example, designed to represent intrathoracic conditions in the two cases, the general arrangement being that described when discussing pleural effusion. A vessel of proper height has a portion of relaxed lung in the lower part, properly connected by tubing through a small outlet near the bottom of the vessel with the source of sound. The top of the vessel is covered with liver. If the space between the lung and liver is occupied by air, the sounds heard over the liver will be distinctly weaker than if the space contains water, and this despite the fact that with the fluid more sound is lost by vibrations escaping through the walls of the vessel than when the vessel contains air. This would indicate that, other things being equal, the pleural effusion should give louder sounds than pneumothorax, with collapsed air-bearing lungs in both cases.

Comparing the sounds over pneumothorax in cases having air-bearing lungs with the sounds over cases of pneumothorax having solid lungs, the differences to be expected would be very decided. Comparing the passage of sounds from relaxed lung to air and from solid tissue to air, the latter offers much more favorable opportunities for the reflection of sound, with the result that much weaker sounds would occur in the latter case after the sounds had traversed the lung-air junction.

Increased Vocal Resonance in Pneumothorax.—As previously stated, this has generally been attributed to the presence of aërial communication between the bronchi, through a pulmonary fistula with the air in the pleural cavity. West asserts that this is not always a satisfactory explanation, claiming that a case presenting increased vocal resonance may, at autopsy, reveal no such communication. The conditions in a case of pneumothorax apparently most favorable to the transmission of sounds next to those associated with a fistulous communication would be encountered when the pneumothorax cavity is separated from direct aërial communication with the trachea by only the walls of a very thin-walled cavity. Thus, the following experiment seems to explain fairly satisfactorily what may occur in cases without any open fistula, presenting an increase in the vocal resonance.

A square block of gelatin, used to represent tissue, is partially excavated through a small opening, the cavity approaching the surface of gelatin directly opposite the opening. One end of a rubber tube is inserted into the opening, the other connected with the vertical limb of a T-glass tube, spoken or other sounds being introduced into one of the horizontal limbs. A solid cylinder of some sort, open at the two ends, plasticine serving the purpose well, is placed with one end upon the surface of gelatin, and separated by a variable distance from the cavity in the gelatin. The other end of the cylinder is covered with gelatin or liver. When sounds are introduced into the cavity in the gelatin, they are audible at the external surface of the material covering the distal end of the cylinder, with an intensity which will vary with the distance separating the interior of the cavity in the gelatin from its surface. If the intervening gelatin is very thin, and exists in this attenuated condition for a considerable area, fairly loud spoken sounds will be heard even through 2 cm. of gelatin covering the distal opening of the cylinder. If only a match-stick opening is made between the air in the gelatin and that in the cylinder, a very marked increase in sound at the external surface of the gelatin covering the distal end of the cylinder is immediately detected.

Applying this experiment clinically, it is easy to see how the marked intensity occurs when there is an open fistula between the lung and the pleural cavity, because the vibrations have only one place where they have to traverse tissue, namely, the chest-wall. Lesser sounds, but still very distinct, might occur if the air in the lung communicated with a cavity with very thin walls immediately beneath the pleura,—preferably a large cavity with relaxed walls. This state of affairs was simulated in the experiment by having the cavity within the gelatin separated from the surface by a very thin partition of gelatin.

The possibility is also to be considered that the increased vocal resonance over pneumothorax may at times partly depend upon factors of reenforcement associated with the air-chamber in the pleural cavity.

ABNORMAL MODIFICATIONS IN THE SPOKEN AND WHISPERED SOUNDS APART FROM INTENSITY.

As is well known, the spoken and whispered sounds may be modified from the normal in pitch and quality entirely independently of whether the intensity of the sounds is normal, increased, or decreased. These modifications may be described as bronchial (to use Flint's term), pectoriloquous, egophonous (applicable only to spoken speech), and cavernous and amphoric, that is, there may be bronchophony, spoken and whispered, pectoriloquy, spoken and whispered, egophony (spoken only), or cavernous and amphoric voice or whispered sounds. The site of origin of these various sounds is predominantly in the upper respiratory tract, where spoken and whispered speech arises. The movement of the air in the lower respiratory tract contributes little, if at all, to the sounds. What effect the air in the lower respiratory tract, whether in bronchial tubes or cavities, has in the development of the ultimate pitch and quality, as well as the intensity, of the sounds, is largely the effect of resonance, and, possibly, to a less extent, that of interference. External to the tubes or cavities it is hard to definitely demonstrate any marked effect on the pitch and quality of the sounds apart from such changes as result from the diminution or elimination of the weaker vibrations of the original sounds. Except for the difference in size and shape of the air-spaces in the bronchi and the cavities, the mechanism of the sounds is the same in both cases, and to a great extent the cavities may be considered as merely dilated tubes.

The general mechanism of these sounds is much the same as that of the breath sounds under similar conditions, and the subject will receive further treatment when those sounds are discussed. But with the voice sounds, especially the spoken sounds, the mechanism is more readily demonstrable than in the case of the breath sounds. In contrast, also, to the breath sounds, there is very much less air moving in the lower respiratory tract to produce sounds in that region in the case of the voice sounds than in ordinary or forced expiration.

The mechanism of the thoracic voice sounds, spoken and whispered, may be diagrammatically represented by blowing through, or speaking or whispering into—the latter by means of a funnel—one end of the horizontal portion of a T-glass tube, while the lower end of the vertical limb of the T-glass tube is inserted into a rubber tube, if the tubal structure of the bronchi is being represented, or else is connected with some more rounded air-space, such as may be had in an atomizer bulb, an excavation in gelatin, or one of the cardiac cavities, if one is studying the mechanism of pulmonary vomicæ. The main source of sound is at the free opening of the horizontal limb of the T-glass tube, if one is simply blowing into the other end, and the sound is obliged to travel in the opposite direction to the air current in order to enter the vertical limb of the T-glass tube. In the case of speaking or whispering the sound travels in the same direction as the air current to reach the vertical limb of the T-glass tube. The pitch of the sounds, after having traversed the walls of the rubber tube or the walls of the imitation cavities, will be found to depend largely on the length and caliber of the rubber tube, or on the size and shape of the cavity. The quality of the original sound will be modified in part by the special fundamental tones or overtones that are reënforced by the air in the tube or cavities. As for the walls of the tube or of the cavities contributing any special quality to the sound, this will depend to a certain extent on the freedom with which these walls can be set into vibration. Unless special resonating effects occur, the shorter tube will give the higher pitch, while the cavity with one diameter the same as the length of the tube will give a lower pitched note than the tube, the sound becoming still lower with increase in diameter of the cavity in any direction.

Spoken and Whispered Bronchophony.—These signs, commonly associated with consolidation and to a less extent with effusion, are to be distinguished from the normal spoken and whispered sounds, according to Flint, by their concentration, nearness to the ear, and by their being more or less raised in pitch as compared to the normal sounds. In other words, we hear sounds more nearly like those existing within the bronchial tubes.

We have already considered some of the possible factors operating to modify these tubal sounds in the normal chest. With the replacement of normal tissue by consolidation or by relaxed tissue, some of these factors are removed. When the consolidation is only near the lung surface, the superficial, and therefore smaller, bronchi alone are united to the chest-wall by the new solid tissue. The farther the abnormal tissue reaches beneath the pulmonary surface, the larger are the bronchi embraced by it, and the more direct is the communication between them and the chest-wall, and not infrequently it is the consolidations surrounding the larger bronchi that give the sounds most resembling those over the trachea itself.

Spoken and Whispered Pectoriloquy.—When the sounds, in addition to the characteristics just mentioned, acquire more or less the character of articulate speech or whispering, the term pectoriloquy is used. This simply means that the sounds within the bronchi coming from the upper respiratory tract are received in more of their original form than was the case with the bronchial voice sounds. The factors conducive to the occurrence of the bronchial sounds are present, only in more marked degree, than in the case of the bronchial sounds. The bronchial sounds are very much those of the trachea without the pectoriloquous element, while in pectoriloquy this element is present, bringing the sounds even more close to those heard over the trachea.

Cases of consolidation and effusion have been considered together, because the mechanism of the sounds heard over them during speech and whispering are often much the same, apart from the factors affecting intensity.

Egophony.—This physical sign has received a disproportionate amount of treatment in works on physical diagnosis as compared to its clinical value. It is more important from the standpoint of the explanation of some of the obscure physical signs than as a clinical aid, for if we possessed an exact explanation of its mechanism, we would have a clearer understanding of some of the other phenomena. Gee gives a number of theories on the subject, including Laennec's, who first described the sign and devoted much space in his writings to it. Flint gave his attention to this subject and concluded that no more satisfactory explanation had been given than by Laennec, who says: "I consider egophonism to be owing to the natural resonance of the voice in the bronchial tubes, rendered more distinct by the compression of the pulmonary texture, and by its transmission through a thin layer of fluid in a state of vibration."

In trying to throw more light on the subject, we found that in some persons it was possible to obtain a considerable degree of egophony by inserting between the opening of the bell of the stethoscope and the skin over the trachea, or, better, over the larynx, a disc of cork about one-fourth inch in thickness. At the same time much of the intensity of the sounds was diminished. This phenomenon was observed particularly in two cases of pleural effusion presenting distinct egophony over the fluid. This result with the cork is apparently due to the reënforcement of the nasal tones in the upper respiratory tract by the cork, which is a distinctly sonorous body, and has a vibration period dependent upon its shape and size. The particular piece of cork used possessed a shape and size conducive to the reënforcement of high-pitched sounds, such as are characteristic of the nasal tone. If the experiment has any significance, it suggests that clinical egophony is the result of some form of reënforcement. As this is carried on best by sonorous bodies, we look for them in the chest, and find them, in the case of effusion, chiefly in the air in the bronchi and in the collapsed lung external to the bronchi. Whether the collapsed lung could be arranged, perhaps through adhesions, to form a proper reënforcing body for the egophonous vibrations within the bronchi, is a matter of conjecture. It seems more likely that the bronchi, with their contained air,—the bronchi in this case being shorter than under normal conditions,—are responsible for the resonance, with increase in intensity of the nasal tones, thus making egophony possible.

Cavernous and Amphoric Spoken and Whispered Sounds.—These sounds are of more value in the diagnosis of excavation than the ordinary teaching would lead one to believe, having the same significance as the cavernous and whispered breath sounds, and at times being present when distinctive breath sounds are lacking. We have already tried to illustrate, by simple experiments, how these sounds are merely the modification of the sounds in the upper respiratory passages affected by the walls and air of the cavity chamber. The subject of the distinctive sound characteristics of excavation will be discussed further under cavernous and amphoric breath sounds. We will only add now that the distinctive signs of excavation, like those of consolidation, are to a certain extent present in the voice as well as the breath sounds; that in the case of the voice sounds they are not modified to any extent by the breath sounds in the lower respiratory tract, including the air passing into and out of the cavities, and that, therefore, in the case of the cavernous and amphoric breath sounds we are not obliged to depend on the sounds produced by air going in and out of cavities for an explanation of cavernous and amphoric breathing. The latter seems a most inexplicable hypothesis, but we may look to the upper respiratory tract for the source of these breath sounds, if not with as much reason as in the case of the voice sounds, yet we may reasonably consider the upper respiratory sounds as being a very important factor in the production of the distinctive breath sounds of excavation.

The following example indicates in a general way how the sounds in the upper respiratory tract are modified by the presence of a cavity. The vertical limb of a T-glass tube is connected by means of an inverted Y-tube with two rubber tubes, one closed at its opposite end, the other, shorter, communicating with an opening in a rubber bulb that has no second outlet. The combined lengths of the bulb and tube in the one case equals that of the tube in the other. Sounds introduced into the horizontal portion of the T-glass tube will be found to be much modified, irrespective of any air currents, as heard over the simple rubber tube, from those heard over the bulb, and will be distinctly lower pitched in the latter case, representative of the cavity, than in the former case, representative of the bronchus within the solid lung.

The Pitch and Quality of the Voice Sounds Heard over Pneumothorax.—The cavity resulting from the presence of air in the pleural space takes part in forming the sounds heard under such conditions, chiefly by modifying sounds introduced into this space from without. In the common condition, that in which the pneumothorax cavity is entirely isolated from any air elsewhere, that is the only effect this cavity can have on the voice and breath sounds. When there is an open fistula connecting the air in the pneumothorax cavity with that in the lung, the conditions in many respects resemble those of ordinary pulmonary cavities communicating with bronchi. When no such fistulous communication exists, the sounds are conducted from the air in the lung through the intervening tissue, and so into the pneumothorax cavity. The vibrations traversing the least amount of intervening tissue will be the ones that will enter the pleural space with most intensity. The vibrations having gained access to the pneumothorax cavity will be modified in pitch and quality, and, under certain conditions, in intensity, according to the nature of these vibrations and the size and shape of the pleural space. The manner in which the pneumothorax cavity affects the sounds which enter it through the tissue separating it from the air in the lung presents no radical differences from the manner in which a bronchus or pulmonary cavity affects sounds coming into them from without, and therefore the subject need not be considered further in this place.

THE RESPIRATORY OR BREATH SOUNDS.

THE GENERAL MECHANISM OF SOUND PRODUCTION DURING RESPIRATION IN THE NORMAL RESPIRATORY TRACT.

The normal respiratory tract may be said to fall naturally into three divisions, architecturally speaking, *i. e.*, the large central tubal system, extending from the larynx to the distal ends of the bronchi, and the portions of the tract at either end of this central system. The first of these divisions presents the most simple and regular arrangement, consisting of a system of bifurcating tubes, the branches usually forming an acute angle with each other and an obtuse angle with the parent stem, and being individually of somewhat smaller caliber than the parent stem. Such an arrangement of this central system, apart from its two ends, does not furnish favorable conditions for sound production as long as the air is circulating freely everywhere and is not moving too rapidly. These tubes, with their contained air, are, however, relatively well adapted to the conduction of air-borne sound, except when they become much reduced in their caliber and the thickness of their walls. On the other hand, beyond the two extremities of this main central tracheobronchial system conditions exist which are extremely favorable to the production of sound in the form of narrowings and widenings of various sorts in the respiratory passages. These variations from the more simple arrangement obtaining in the central portion of the respiratory tract are chiefly of three kinds in relation to the direction of the air-current. A portion of the tract may become widened, as when the air passes from terminal bronchus to vestibule, or it may become constricted, as when the air passes in the reverse direction, or it may possess a narrowing with wider portions to either side, as in the case of the glottis. The moving air sets into vibration the walls forming the first portion of the relatively dilated or narrowed channel, either by direct impact or by suction eddies as described by Sahli for murmurs produced under similar conditions in the circulatory system. The sounds produced as the air passes from a larger to a smaller space are usually much fainter than those just described. The relative weakness of the sounds under these circumstances is due to the fact that a smaller portion of channel wall is set into vibration, thereby producing vibrations of less amplitude. The sound arising as a result of a projection into the air channel, as in the case of the vocal cords, is due to the direct impact of the air on the cord margins, and perhaps also to the air passing from the relatively narrow glottis to the wider space beyond.

The important part played by the rate of the air-current in the production of sounds should always be recognized. By the rate is meant the amount of air passing through a given space in a given time. Thus the air passes more rapidly through the glottis during speech than it does to either side of it.

The mechanism of the sounds due to the air in the respiratory tract has many analogies to that of the sounds instituted in the circulatory system. Thus neither the air in the one case nor the fluid in the other case contains the original sound vibrations, but each sets into vibration certain tissues which actually contain the original vibrations of the sounds as we hear them. It is the vibrating vocal cords or the cardiac valve projecting into the blood-stream that, at least partly, form the original vibrations of the speech or the cardiac murmur.

It is well to recall that the sounds produced in the various parts of the respiratory tract may really be composed of a number of sounds of different character.

Just as in the case of our study of the voice sounds heard over the chest we found it advantageous to begin with some knowledge of the voice sounds over the trachea, so in the case of the breath sounds, and to a certain extent for the same reasons, it is advisable to introduce the subject of the breath sounds with a study of the respiratory sounds audible over the trachea.

THE TRACHEAL RESPIRATORY MURMUR.

By the tracheal respiratory murmur is meant the sound heard over the trachea of a normal person during quiet or slightly forced inspiration and expiration. The term is not intended to convey any notion as to the origin of the sound.

Before attempting to determine the origin of this sound it is necessary to know its clinical characteristics, and the points of contrast between it and vesicular or pulmonary respiration. Flint's summary of his most excellent treatment of the subject follows:

TRACHEAL OR LARYNGEAL RESPIRATION.	VESICULAR RESPIRATION.
INSPIRATION.	INSPIRATION.
1. Tubular in quality.	1. Vesicular in quality.
2. In duration falling somewhat short of the inspiratory act.	2. Longer in duration.
3. High in pitch.	3. Low in pitch.

EXPIRATION.	EXPIRATION.
1. Uniformly present in tracheal respiration.	1. Absent in about one-third of the cases.
2. Generally more intense than the inspiration.	2. Intensity much less than the sound of inspiration.
3. As long or longer than the sound of inspiration.	3. Much shorter than the sound of inspiration.
4. Higher in pitch than the inspiration.	4. Lower in pitch than the inspiration.
5. The inspiration and expiration separated by an interval.	5. The inspiration and expiration continuous.

The only parts of this brief summary of Flint's description of the tracheal murmur that might be added to, relate to quality and pitch, and we speak of these subjects because they have direct clinical interest. Any one who has listened over a considerable number of tracheas (a performance, by the way, that is very instructive) must be impressed with the wide variations in pitch and quality of the sounds heard in this locality in different persons. Marked differences may occur in those of the same age, and even in the same individual. Occasionally the usual order is reversed, and the tracheal inspiration is distinctly higher pitched than the expiration. On more than one occasion we have pointed out to others breath sounds over the chest which they admitted were very strongly suggestive, if not indicative, of excavation, and we have then demonstrated sounds equally cavernous over the tracheas of the same patients. One can at times clearly distinguish at least two kinds of sounds occurring synchronously during tracheal respiration. There is, however, a fairly uniform type of breathing audible over the trachea in the majority of cases, having many points in common with the ordinary bronchial breathing of consolidation, though being usually, in our experience, rather harsher and lower pitched than the pneumonic type. It is important to have in mind that the tracheal respiration is a composite sound, containing many different sorts of vibrations.

The Sources of the Tracheal Murmur.—In the investigation of any sound audible over an even caliber tube like the trachea, the possible sources of the sound naturally fall into three anatomical divisions—first, the sounds produced by the air moving in the tube itself; second, the sounds produced on one side of the point auscultated, either at the termination of the tube or at one or more irregularities in the air-passage, and, third, the sounds produced in a similar way on the other side of the point auscultated. As to the first source, it is readily demonstrated that a current of air of considerable force is requisite to produce a sound of any intensity in an even and smooth bore tube, provided it is long enough to exclude the sounds made at its two ends, and we do not think that the current of air in the trachea is strong enough to give rise to a sound made in the trachea itself, or, if it can produce such a sound, that it will be intense enough to compete with the sounds made elsewhere. Whatever increase in the rate of the air flow occurs will be felt just as much by these other sites of sound production as by the tracheal walls themselves. But while the trachea may be eliminated as an important site of sound production, it acts to some extent as a resonating chamber.

Besides the trachea itself, and the tracheolaryngeal junction, two general sources of sound are to be considered,—those above the trachea, the hypertracheal, and those below, the hypotracheal.

The Hypertracheal Sources of the Tracheal Murmur.—Above the trachea we may divide the sources of sound into the glottic and hyperglottic, these sites requiring consideration in both inspiration and expiration. During quiet inspiration the glottis is nearly stationary, and opened to the extent of from 3 to 5 mm., the gap increasing with more rapid inspiration. Now, while the glottis may exert a marked influence on the inspiratory tracheal murmur, it does not always do so, especially when the air current is of only moderate rapidity. This becomes more intelligible when one listens over a tube through which air is passing, and notes how much constriction of the tube is necessary before much additional sound is obtained. The degree of separation of the vocal cords during inspiration explains to a great extent why the inspiratory sound is usually less intense than the expiratory. It is difficult, during inspiration, to effect voluntarily the close approximation of the vocal cords that can be obtained during expiration with the same amount of air flow. In addition to the sounds produced directly by the vocal cord margins themselves, there are probably vibrations set up to either side of the vocal cords. One of the best ways to study the glottic murmur is with the mouth wide open and the nasal apertures closed. The glottic sound, both inspiratory and expiratory, is considered by many, though not by all, as the main source of the tracheal murmur.

The glottic expiratory sound is more prominent than the inspiratory one, and is usually quite a distinct sound, as one might expect from the relatively close approximation of the vocal cords during expiration. It certainly plays an important part in the tracheal expiratory murmur, its relative importance being the only matter for discussion. One may at will bring the cords much closer together than occurs usually in expiration, with the production of a still louder and higher pitched sound, but care must be taken to avoid bringing the palatal muscles into contraction at the same time.

The Hyperglottic Sources, Inspiratory and Expiratory, of the Tracheal Murmur.—By these sounds we mean particularly those produced in the pharyngeal regions, in the mouth, at the lips and teeth, and, during nasal respiration, within the nasal chambers and at the nasal apertures. These sources figure more prominently in some individuals than in others, but they appear to play a greater part than is commonly accredited to them. Marked differences will be obtained over the trachea in some individuals by changing from oral to nasal breathing, or by widely opening the mouth, or by placing a large tube between the teeth to eliminate labial and dental sounds. But, however plain these sounds produced above the glottis may be, we can usually detect, in addition to them, sounds produced below the hyperglottic area. It will be noticed that regions exhibiting marked narrowings and widenings are particularly favorable to sound production above the glottis, as elsewhere.

Hypotracheal Sources of the Tracheal Sound.—Inspiration.—If one should begin his studies of the breath sounds, both experimental and clinical, with a thorough understanding of the site of production of the pulmonary inspiratory sound and its character and intensity, then, when he would come to investigate the tracheal sound in the episternal notch, he would undoubtedly ascribe to the pulmonary sound an influence upon the tracheal sound. If one listens to the sounds coming from the tracheas of living animals, or the sounds in a tube connected with the tracheas of animals, or connected with their lungs after removal from the body, during the expansion of these lungs, and while they are producing a vesicular murmur, the effect of this pulmonary sound upon the tracheal or tubal sound is very striking, the more so if the tube is of sufficient length to eliminate the sound at its free end. This pulmonary sound is certainly not the only sound heard over the trachea during inspiration, and it may be very difficult to isolate it from the other sound or sounds present, but we are convinced that it does play some part in many persons, especially during fairly quiet breathing and in children, and if the person auscultated tries to eliminate the purely glottic and hyperglottic sounds. The vesicular sound may have something to do with lowering the pitch of tracheal inspiration. The difference in pitch between the tracheal and pulmonary inspiratory sounds, though usually decided, is not always very marked; and at times they approximate each other closely during quiet respiration. Moreover, the vesicular inspiratory murmur is higher pitched directly at the pulmonary surface than over the exterior of the chest, as revealed by animal experiments.

The Hypotracheal Source of the Expiratory Tracheal Sound.—The sound heard over the normal chest during expiration, granting that it is ever produced in the lungs, must be so feeble that it could not have much effect on the tracheal sound, especially in the presence of other more potent sources of sound. Experimentally, as well as clinically, we have no reason to believe that the pulmonary sound has anything to do with the sound we hear over the trachea during expiration.

It will thus be seen that the so-called tracheal sound may have many sources, and that the trachea itself may play a very small part in its production, though through resonance it may affect the pitch and the quality of the sounds. The glottis, especially during expiration, may play a very important part. The parts above the glottis, and, during inspiration and to a less extent, the pulmonary region, may exert an influence on the sound heard over the trachea.

The importance of investigating the sources of the tracheal sound will be especially appreciated when some of the sounds heard over the lungs are considered. Thus, in discussing the claim made that the sound heard over the trachea is essentially that audible over consolidation, we are prepared with two important facts, first, that the tracheal sound is subject to considerable variation in quality, pitch, and intensity, and, secondly, that the tracheal sound presents for study a number of possible sources for its production.

In considering the sounds heard over the trachea during respiration, no attempt has been made to enlarge on the subject except to the point of trying to determine how much of this sound is produced above the tracheobronchial level and how much below, and also how intense the sound produced above this level is. Our conclusion is that, apart from any influence below the trachea, there are sounds produced during inspiration and expiration in the upper respiratory tract, the exact location of which is a matter of secondary importance, sounds of such magnitude that they have always to be borne in mind in considering the possible sources of sound heard during respiration over the lungs, whether in a healthy or diseased state.

Before leaving this subject we wish to refer to a fact, which we will find occurring in a number of guises under different circumstances, so that it may be considered representative of a general principle, and that is, that whenever a sound is heard over a tube or over the body as a result of fluid or air setting up vibrations in the tube or other structures, these vibrations in the walls or other solid structures set up sound vibrations both in the contiguous solid structures and in the air or fluid. As applied to a rubber tube with vibrating walls, not merely walls that are conducting vibrations, this means that the walls of the tube vibrate and produce sounds not only at their surface or at the surface of an object overlying the tube, as a direct effect of the initial tube vibrations, but also in the air or fluid contained within the tube. Now, while this latter sound in the air or fluid may not be of much importance directly external to the portion of the tube that is vibrating, it is all important at some distance beyond in the tube where the original tube-wall vibrations have ceased to operate. As applied clinically we find, for example, that a sound originating, say, at the glottis, will be heard directly over the site of origin with relatively great intensity as a result of these initial vibrations in the tracheal or glottic structures. But any sounds transferred from these regions to the lungs will be simply the air-propagated vibrations coming from the air originally set in vibration by the vibrating glottic structures or trachea. In other words, the sound is attenuated at a distance from its source, partly because those vibrations existing in the tissue and directly derivable from tissue have disappeared.

THE NORMAL VESICULAR OR PULMONARY MURMUR.

The normal vesicular murmur, the term originated by Andral, will be applied in the ordinary sense to the normal respiratory sounds as audible over most of the chest-wall covering the lungs. The term is not used in this particular place to indicate or suggest a peripheral or pulmonary source for the sound.

The term "pulmonary" murmur might be used with equal justice, signifying the sound heard over the normal lungs, and also without any intention to indicate its origin. Whichever term is used, it will be employed in a purely anatomical sense, as signifying the sound heard over the normal vesicles or normal lung. The expiratory "vesicular" or pulmonary murmur apparently does not arise in the lungs at all, though it is modified by its passage through them.

The character of the vesicular sounds is too well known and too well described elsewhere to render necessary any comment in this particular place, though various characteristics will be alluded to from time to time as they come up for discussion. Flint's comparative table, showing some of the contrasts between the sounds as heard over the neck and over the lungs, has already been given.

In the attempts to solve the problems associated with the study of the vesicular murmur, a number of explanations have arisen both as to how the murmur is produced and as to the site or sites of its production. Thus, the different parts of the respiratory tract, the mouth, the nose, the larynx, the trachea, the bronchi, large and small, and the vesicles, either alone or in various combinations, will be found to have their own special advocates, as being the site or sites where vesicular breathing originates. In addition, some authorities give one source for the inspiratory and another for the expiratory murmur, and, finally, different sources for different parts of the inspiratory murmur have been suggested.

The majority of those interested in this subject have maintained that the normal inspiratory murmur arises within the larynx and trachea, and possibly also above this, or within or near the vesicles, or that it arises at both these extremities of the respiratory tract. The expiratory murmur has generally been attributed to an origin within the upper respiratory tract. Those upholding the source in the upper respiratory tract believe that the vesicular murmur is simply the superior sound, altered in character and weakened in its passage through the lungs to the surface of the chest, somewhat as is the case with the voice sounds. Penzoldt believed he had confirmatory evidence for this idea in the marked softening and weakening of the laryngeal sound obtained when lung tissue is placed over the neck, but he failed to appreciate that even in this experiment inspiration and expiration maintain the relative pitches found directly over the trachea, the inspiration still being lower pitched than expiration, if this condition existed directly over the trachea, which is the reverse of the state of affairs met with at the chest surface.

The evidence on which our conclusions are largely based in regard to the source of the vesicular murmurs, particularly the inspiratory one, is summarized in the following examples, which have been numbered for easy reference:

Ex. No. 1: A tracheotomy tube in the trachea of a patient sufficiently accustomed to its use is associated with a normal vesicular murmur over the chest, both inspiratory and expiratory. This fact, long known, has been observed in two cases by one of us. In a third case the sounds over the trachea could be materially altered by removal of the tracheotomy tube, while the sounds over the chest remained unchanged. Of course, it is not to be overlooked that, while the source of sound in the upper respiratory tract is removed, a source for sound exists at the mouth of the inserted tube, particularly during expiration.

Ex. No. 2: Removal of the larynx in living animals, or manipulating it in a variety of ways, does not seem to affect the inspiratory vesicular murmur except under very special circumstances, which do not occur in connection with the normal larynx. In our own experiments manipulating the trachea of a rabbit or a tube inserted in the trachea did not affect the inspiratory chest sounds except under very unusual conditions.

Ex. No. 3: In Sahli's living human cases, where straining was employed with the glottis closed, a murmur in character distinctly of the inspiratory vesicular type was produced during expiration, that is, during distention of this particular part of the lung, audible (1) in a man over a pulmonary hernia due to a congenital fissure of the sternum, and (2) in a man over the apices of markedly emphysematous lungs, also in the act of expiration and during straining.

Ex. No. 4: Bullar constructed an apparatus of such a character as to contain a lung, and at the same time to exercise negative pressure on its surface, the trachea communicating freely with the external air. The larynx had been previously removed. This apparatus he called an artificial thorax, and by means of it he was able to inflate and deflate the lung to any degree desired, and under conditions satisfactorily approaching the normal. The stethoscope in contact with such a lung, according to Bullar, revealed a normal "inspiratory" murmur and a faint "expiratory" sound. If one lung is placed in the apparatus while the other is outside, but both still attached to the trachea, and the trachea "plugged while the inner lung is in a state of inspiration, and the machine kept in motion, both lungs 'breathe,' 'expiration' and 'inspiration' alternating in the two." Moreover, Bullar also emphasized the point that the vesicular murmur over the chest is loudest during inspiration, the very time when the conditions in the lung, namely, those due to its distention, are most unsuited for transmission of the laryngeal sound.

Ex. No. 5: If a calf's or sheep's lung is removed from the body and a tube inserted into a bronchus and the lung fairly well distended, further inflation, followed by deflation to the original point of distention, will produce very distinct "inspiratory" and perhaps "expiratory" sounds, the former being relatively loud, high pitched, and prolonged, and produced within the lung, the latter, when present, faint, low pitched, and brief, and apparently due to the external tube opening and not to the lung itself. The sound of the air passing through the tube itself, or produced in the vicinity of the external tube opening, provided the tube is of sufficient length, is not definitely audible during "inspiration," nor, in fact, during expiration, over the lung surface. This fact, and the fact that even in a small animal, like a mouse, either before or after death, and with or without a tube inserted in the trachea, vesicular sounds are audible, indicate in what a small and peripheral portion of the lung inspiratory sounds may be produced. The sound over a lung removed from the body becomes lower pitched, weaker, and more like true vesicular breathing if some substance like liver or gelatin is placed between the lung and the stethoscope. In the same way if the chest-wall of a living animal is removed, only enough being left to maintain the visceral pleura in position, the sounds are much louder and somewhat higher pitched than if the chest-wall has not been interfered with. This holds true if the larynx has been removed and a soft-rubber tube inserted deeply into the trachea.

Ex. No. 6: If one listens over the surface of a breathing rabbit with a rubber tube fitted into the trachea, the usual inspiratory murmur is heard over the chest. If into the free end of this rubber tube the vertical limb of a T-glass tube is inserted, and air blown forcibly through the horizontal limbs, a faint sound resembling bronchial breathing will be heard over the chest if the new sound in the T-glass tube is sufficiently loud. But at the chest surface the vesicular inspiratory murmur is louder than the new sound heard here, although the new sound in the trachea is louder than the one existing in the trachea before the addition of the T-glass tube.

Again, sounds of considerable loudness, such as blowing and whispering, made in a T-glass tube as in the above experiment, the vertical limb in this case being inserted into a rubber tube fitting into the trachea of a relaxed lung outside the body, will be found to be fainter, even over this relaxed lung, than the inspiratory sounds heard over the same lung in a state of distention during inflation.

Ex. No. 7: Section of the pneumogastric nerves in horses, according to Bondet, results in the total disappearance of all peripheral sound, though respiration continues and the sounds over the trachea are augmented. This elimination of the peripheral sound does not hold true for rabbits after section of the vagi.

Ex. No. 8: There is no constant relation between the intensity of the laryngeal and the inspiratory vesicular sounds—either may be weak while the other is strong. This may be observed in health and in cases of unilateral and bilateral emphysema, and in cases where only one lung is functionating. In these last cases vesicular inspiration may be louder than the inspiration heard over the trachea.

Ex. No. 9: While tracheal expiration is usually louder than tracheal inspiration, vesicular expiration is not only much weaker than vesicular inspiration or is absent, but is with much more difficulty intensified than vesicular inspiration.

Ex. No. 10: The whispering sound over the normal trachea, though usually even louder than the breathing sounds in this position, is not heard, or is only very faintly audible, where normal vesicular inspiration occurs.

Ex. No. 11: Over the trachea expiration is generally higher pitched than inspiration, while the reverse relation is found where vesicular breathing occurs. The usual order is: highest pitch, tracheal expiration; next, tracheal inspiration; next, vesicular inspiration; and last (lowest pitch), vesicular expiration.

Ex. No. 12: Vesicular inspiration is longer than tracheal inspiration, and there is no interval between inspiration and expiration over the chest, while such a pause does occur over the trachea (Flint).

Ex. No. 13: The quality and pitch of the sound heard over the trachea may at will be considerably altered in many cases, while these characteristics in the pulmonary sounds usually remain more constant.

Ex. No. 14: If a sufficiently long tube is inserted in the trachea of a breathing rabbit, and into the free end one of the horizontal limbs of a T-glass tube is inserted, the other end being connected with a second long rubber tube, while the vertical limb is covered at its lower end with thin membrane, there will be no sound heard over this membrane while the rabbit is breathing normally, provided the rubber tubes are long enough to exclude sounds at the ends distal from the T-glass tube. This furnishes evidence that appreciable sounds are not produced in the interior of the bronchial tubes, though it leaves open the question of sounds produced at the bifurcation of tubes.

The evidence furnished by the various examples just presented will be directed toward solving where and how the pulmonary or vesicular sounds, chiefly the inspiratory sounds, are produced. The importance of Ex. Nos. 9, 10, and 11 in clearing up the subject of the source of the inspiratory vesicular murmur we have not seen alluded to anywhere previously. All the conclusions in the literature based upon experimental work have applied chiefly to the inspiratory vesicular murmur.

The three main regions to be studied as possible sources of the vesicular or pulmonary murmur are the upper respiratory tract, beginning no lower than the upper portion of the trachea, the vesicular region, that is, the region beyond the terminal bronchi, and the portion between these two extreme regions, the portion consisting of trachea and bronchi with the bronchioles.

The Inspiratory Murmur in Relation to the Upper Respiratory Tract.—Any one who can directly study the experimental evidence furnished, especially Ex. Nos. 1 to 8, must be convinced that a relatively loud murmur is, or may be, produced during inspiration in the lower respiratory tract, entirely apart from any influence, normal or artificial, provided the artificial sounds are not too loud, that exists in the upper respiratory tract. Such a loud sound as is heard peripherally during inspiration could not come entirely from the upper respiratory tract unless distinctly louder sounds were audible over the chest during expiration than normally occur there. All those who have had the opportunity to make proper experimental investigations, which includes a number who have attended our experiments, support the view that the inspiratory vesicular murmur has a peripheral origin. Laennec, Skoda, Walshe, and Flint, though differing among themselves on many important points associated with auscultatory phenomena, and though not agreeing as to the exact source of the vesicular inspiratory sound, were as one in attributing its origin to the lower respiratory tract. With no convincing evidence to the contrary, it seems unnecessary to devote more time to the subject.

The Relation of the Lower Trachea and the Bronchi to the Vesicular Inspiration.—The lower trachea, the bronchi, and the bronchioles present a system of branching cylindrical tubes, the branches usually making an acute angle with each other, and their individual sectional area being smaller, though their combined sectional area is slightly larger, than that of the parent stem. The interior of these tubes is smooth and moist. With the rate of air flow that exists in the lungs, do these tubes present the requirements for the production of a sound of sufficient intensity to be appreciated by ordinary methods? For this study the tubal tree may be divided into the tubes proper and the regions of bifurcation, while the tubes may be classified as large and small. With any ordinary rubber tube, listened to over an area sufficiently distant from its extremities to exclude any sounds that may be produced at the extremities, little or no sound is audible if the rate of air flow is no greater than that of respiration as practised during auscultation of the normal chest. The same thing is demonstrated by Ex. No. 14. That the larger tubes in the living being may be dispensed with as a source of appreciable sounds seems borne out by Ex. Nos. 3, 5, and 7. In Sahli's cases (Ex. No. 3) a murmur of good inspiratory vesicular character was produced in a comparatively distal portion of the lung. The same is true of Ex. No. 5. As for the sounds that might arise in the smaller bronchi, there is no reason why the normal air current should produce sounds in these tubes loud enough to be audible. Certainly if they were capable of producing the inspiratory vesicular murmur, we should hear a much louder expiratory murmur than we do from the passage of air through them during expiration.

Near the sites where the bronchi bifurcate better opportunities for sound production might seem to occur than within the tubes themselves. But the physical conditions here are not favorable, much as the conditions are not favorable for circulatory sounds where arteries branch. The pressure is too constant to cause vibrations of any intensity in the bronchial walls, either through eddies producing suction, or through direct impact of the air against the walls. If one uses a Y-glass tube, the lower limb being larger than either of the upper two, and the bifurcation internally being made to represent as closely as possible that of a dividing bronchus, and if one attaches long tubes to all three branches, very little sound will be heard over any one of the tubes when the air is passing through in a manner simulating that of respiration. Ex. No. 7, if dependable, indicates that no appreciable sound is produced in the central portion of the bronchial tree. Our examples, and the fact that the expiratory murmur over the chest is so much weaker than the inspiratory, argue against any influence from the bronchial source on the normal vesicular inspiratory sound.

The Relation of the Vesicular Portion of the Lung to Vesicular Inspiration.—That the vesicular inspiration does not arise in the tubal structure of the lower respiratory tract is borne out by all physical laws, and, with the exception of possibly the most distal portion, is supported by all our experiments. On the other hand, both theory and experiment support the belief that this sound originates in the vesicular portion of the lung, that is, in the relatively enlarged and distensible spaces situated distal to the bronchi. Granting that the inspiratory murmur is produced somewhere in the lower respiratory tract, and that at least the major part of the sound is undeniably so produced, the vesicular portion is the only part of the lower respiratory tract that furnishes conditions sufficiently different during inspiration and expiration to account for the marked intensity of the inspiratory murmur as compared to the expiratory. This general subject need not be pursued further. Whether the sound is produced as the air passes beyond the distal end of the terminal bronchus or even farther along than this will be discussed later.

The Expiratory Vesicular (?) or Pulmonary Murmur.—This murmur, on account of its faintness and lack of distinctive characteristics, is particularly difficult to analyze. From the literature we only obtain indirect help in solving the problem, as most of the conclusions met with, while presented in relation to vesicular breathing, will really be found to apply only to the inspiratory phase. As to where the expiratory sound over the chest arises, there seems to be unanimous consent in tracing it to the upper respiratory tract, though no convincing proof has been furnished. Gee attributes the expiratory murmur to the sounds produced in the glottis, because he assumes that the sounds heard during whispering over the chests of normal individuals are produced in this way, but not even the latter point does he establish.

The Relation of the Upper Respiratory Tract to the Normal Pulmonary Expiration.—Perhaps the main clinical evidence bearing on the subject is this. In those in whom a faint expiratory sound is heard over the chest, and also a faint sound of about the same or greater intensity on whispering, the two kinds of sounds heard over the trachea may likewise have the same relative intensity. The whispered and expiratory sounds have much the same intensity, the former usually being the louder, although the amount of air being expelled per unit of time in each case is vastly different, the amount during simple expiration being in excess of that during whispering. This means that less air is circulating in the lower respiratory tract during whispering than during the act of expiration, and any sound produced in the lower tract would be much fainter during whispering than breathing. But we do not find that the expiratory sounds, even if somewhat forced, are the greater ones over the chest; in fact, the whispered sounds are often actually the louder ones.

Naturally, the first method of testing out the prevailing views is to exclude all sound made in or above the trachea, and to see if any sound still remains over the lungs during expiration. This has not been done in any of the experiments found in the literature. While the laryngeal and hyperlaryngeal sources may have been excluded by operations upon the upper respiratory tract, the possibility for sound production has always remained at the opening of the trachea or of a tube entering it.

The following experiments have been designed to overcome this difficulty.

A rabbit under ether with a distinct expiratory as well as inspiratory chest murmur was used. Over the trachea a very plain expiratory as well as inspiratory murmur was audible. After the introduction of a rubber tube into the trachea long enough so that any sound at the free end of the tube could be eliminated as a source of sound over the chest, the expiratory chest murmur disappeared, though the inspiratory murmur persisted unchanged. With the same tube in the trachea after death the lungs were forcibly expanded by inflation, and the chest-walls immediately allowed to collapse. During this rapid deflation no sound was heard over the chest.

With lungs outside the body approximately the same results are obtained, provided the precaution of using a sufficiently long tube is observed. If a portion of lung is expanded and then allowed to collapse, little or no sound is heard during deflation unless as a result of sound produced in the rubber tube—too little sound to reach the external chest-wall. A possible source for sound exists where the sectional surface of the end of the rubber tube projects into the bronchus.

Is there any reason why sounds as weak as those heard over the trachea during expiration or whispering should not be transmitted, however weakly, through the lung and to the chest surface? If a short rubber tube is inserted into the external opening of a tracheotomy tube *in situ*, and one blows with moderate intensity across the external opening of the rubber tube, the sounds thus produced are audible over the chest during suspended respiration or during expiration. Again, if one inserts the vertical limb of a T-glass tube into a rubber tube introduced into the trachea of a rabbit, a sound of moderate intensity made at one end of the horizontal portion of the T-glass tube, while the other end is blown into from some one's mouth, which holds it tightly, will be faintly heard over the chest.

Is the fact that the sounds in the upper respiratory tract have to be carried against the air current evidence opposed to this region as a source for the expiratory murmur? The voice sounds are practically always carried in this way, and likewise the expiratory breath and the whispered sounds in cases where they are audible over consolidation or fluid. Such a contrary current can only exert a minor influence. This can be readily shown with a T-glass tube, one end of the horizontal portion of which is attached to a long rubber tube, the other end being placed in the mouth. A shorter second rubber tube, closed at the lower end, is attached to the vertical limb of the T-glass tube. Sounds a long distance from the T-glass tube made in the long rubber tube attached to it will be audible over the second rubber tube, though the air coming from the mouth be directed away from the region auscultated.

Finally, are the differences in pitch of the tracheal murmur and of the pulmonary expiratory sound evidence that the former is not the source of the latter? Judging from the voice and other sounds introduced into the trachea, the sounds heard over the normal chest are much lower pitched than at their source. Apparently certain tones of a rather low pitch are the ones that are transmitted best, as in the case of the voice. In this connection it is well to recall that the breath and whispered sounds in the upper respiratory tract, like the voice sounds, really include many tones, and while we describe the complex sound as having one particular pitch, this refers to the pitch that is most emphasized.

The Tubal Portion of the Respiratory Tract.—While this portion of the respiratory tract certainly does not produce the relatively loud vesicular inspiratory murmur, might it produce the much weaker expiratory murmur? To answer this we must refer to what has gone before. Experimental evidence seems opposed to there being a source for appreciable sound in the normal lower respiratory tract, and this seems upheld, as far as the tubal structure is concerned, by what we know of sound production in tubes arranged in this way, with air circulating in them at the usual respiratory rate.

The Vesicular Portion of the Respiratory Tract.—This also being part of the lower respiratory tract, whatever evidence has been furnished against the supposition that the whole lower tract is the source of the normal expiratory pulmonary sounds is opposed to the idea that the vesicles can account for it. The conditions for sound production in this region during expiration are at best very unfavorable.

If the expiratory, so-called "vesicular," murmur is produced in the upper respiratory tract, how shall we account for the increase in intensity of expiration in cases of complementary emphysema, when the amount of air passing through the upper respiratory passages is not increased, and the sounds over the trachea are at least no louder than the normal ones in this region? One can only suggest a number of possible, if not very satisfactory, explanations, one or all of which, acting together, might solve the problem. First, there is the increase in amount of air per unit of time in the compensating lung as compared to the normal lung, when the air is flowing in the lung toward the mouth. Secondly, there is the possibility of Bullar's "third sound" occurring where the air in the main bronchus on the normal side enters the trachea, little or no air in this case coming from the affected side. Thirdly, with the increased activity on the compensating side, there may be some degree of bronchitis sufficient to produce the sounds we hear. In bilateral emphysema the expiratory sounds undoubtedly have at least a partial origin in the lower respiratory tract, though the actual air flow per unit of time is less than normal. Associated bronchitis or abnormal modifications in the shape of the respiratory passages under these conditions may be responsible for these sounds.

Summary.—Our conclusion is that the normal pulmonary inspiratory murmur is produced entirely in the lower respiratory tract, and distal to the bronchi, and that the expiratory murmur is usually, if not always, the transmitted sound from the upper respiratory tract.

To attempt to analyze more closely where and how the vesicular murmur is produced would mean to enter the field of speculation, and the subject will receive but scant attention here. Shall we believe that the sound arises in the air-sacs or in the air-cells, or even in more than one of these structures, and shall we assume that the murmur is due to the passage of air against the tissue walls, or to suction exerted on the walls, or that it is caused by stretching of the walls of the air-cells, or by friction of the vesicular walls against one another, just as part of the sound is supposed to be produced in a moist sponge during contraction and expansion of the sponge by the friction of the spongy fibers?

Laennec and Skoda had the same conception of the origin of vesicular inspiration, believing it to be due to the friction of the air in the pulmonary alveoli, or the resistance of the air-cells to the air.

Walshe believed the sounds arose in the vesicles and smaller bronchi, but was much perplexed about the different intensities of inspiration and expiration. "I can only suggest," he states, "as a tentative solution of the problem, that the excess in loudness and duration of inspiration sound over expiration sound depends upon the current being in the former instance directed toward, in the latter from, the ear of the observer." This explanation is, of course, untenable on physical grounds in trying to account for the difference in intensity of inspiration and expiration as heard over the chest. If Walshe's suggestion were true, then expiration should be louder than inspiration when one listens over a tube inserted into a trachea or bronchus attached to expanding and contracting lungs, which is not the case if the tube is long enough to eliminate the sound made at the end distal to the lung.

Flint, speaking of normal vesicular inspiration, asks: "May not the peculiar quality be owing to the separation of the sides of the cells and the capillary tubes, which, to a greater or less extent, come into contact, and, owing to the moisture of the tissues, are slightly adherent during the collapse of the lung incident to expiration?" Later on Flint says: "It is noteworthy that Laennec, in describing the differences between the vesicular murmur and bronchial respiration, says that the latter loses the 'slight crepitation' which belongs to the former. The expression 'slight crepitation' distinguishes more accurately than any other term the peculiar quality of the vesicular murmur, and, at the same time, it denotes the mechanism of its production." Flint thought he established his point by results obtained on listening to sounds over lungs outside the body inflated by the tracheal route. "If the stethoscope be placed directly upon the lungs, or with a folded napkin intervening, with each inflation a crepitating character of the sound is apparent. The inflation of portions which contained but little or no air, *i. e.*, collapsed portions, gives a perfect representation of the crepitant râle. Now if the intervening folds of cloth between the stethoscope and the chest be sufficiently increased in thickness, the crepitating character is modified, and the quality becomes hypervesicular; in other words, we obtain an intensified representation of the vesicular respiration." In his earlier writings Flint gives a wider area for the origin of the vesicular sounds, including the bronchial tubes, and in some cases the trachea.

One would hesitate before arraying himself against a clinical observation made by both Laennec and Flint, but it seems difficult to read into either the normal inspiratory or expiratory murmur anything suggesting crepitation, or "granular" breathing, or anything in the nature of an interruption or roughness in the course of normal smooth vesicular respiration. Such a "crepitating" element may at times be introduced into the breathing of normal individuals, but we do not believe it is characteristic of the vesicular sound in its pure form. Even Flint himself states, in speaking of the lung outside the body, "the crepitation may disappear after the inflations by means of the bellows have been continued for some time." And he also says that vesicular breathing "is not unlike the sound of the expired breath from the open mouth," which assuredly does not possess any crepitating quality. For our part, the inspiratory murmur appears to be as free from any such quality as the expiratory. It is, moreover, difficult to understand how the respiratory murmur produced after the lungs are already well inflated could be due to the expansion of vesicles collapsed to the extent that their walls are still in contact.

Bondet (1863) seems to us to have expressed more clearly than any one else how the normal respiratory sounds are produced. According to him all the physiological bruits are the result of a "*veine fluide sonore*," which is produced at the moment when the air passes from a narrower to a wider portion of the respiratory tract. He considers such sounds are produced either in the upper respiratory tract, the superior bruits, arising in the larynx or above it, or in the lower respiratory tract, the inferior bruits, which he describes as a single bruit produced at the point of opening out of the final branches of the bronchial tree into the vesicles.

The first step toward an understanding of the mode of production of the pulmonary inspiratory murmur consists in listening during inflation and deflation over a lung removed from the body. We have employed chiefly sheep's and calf's lungs, but other lungs are as satisfactory, or nearly so, such as the human lung and the lung of the rabbit, the cat, and, to a certain extent, of the mouse, all of which lungs suggest a mode of production of the murmur essentially the same.

The objection may be raised that the lung expanding under positive pressure might not produce the same sounds as if normal negative pressure were operative, but whenever negative pressure is used, the results appear identical with those obtained with positive pressure. Thus the removed lung expanding under positive pressure when well distended gives the same character of sound as in the living subject. Bullar, who provided negative pressure external to lungs, obtained results like those furnished under natural conditions.

One may listen to a removed lung during expansion and contraction either with the stethoscope applied directly to its surface or separated from the lung by water to make sure that all sound from surface friction is eliminated. Or, if the stethoscope is close enough to the lung, there need be nothing between it and the lung except air. The results in these different cases are, for our purposes, identical, though the intensity of the sounds may vary. In the second method the lung or portion of lung is submerged at the bottom of a suitable vessel, the lung being connected with the exterior by a rubber tube entering at the lower portion of the vessel, and fitting tightly into the trachea or one of its divisions or subdivisions. It is essential that only pulmonary surface come in contact with the water, to avoid the escape of sounds from the tubal structure, whether bronchial or rubber. For the reception of sounds a single piece of rubber tubing closed at its inferior opening is likewise submerged in the water, while the upper end is attached to the vertical limb of a Y-glass tube, the remaining limbs of which are attached to the rubber tubes of the stethoscope. Or the bell of the stethoscope may be applied to the surface of the water if the distance from the lung is not great.

When a lung removed from the body begins to expand, one hears little except sounds exactly like a certain type of râle, of fairly large size, and rather low pitched, and truly crackling in character, audible only during "inspiration." With the further development of the expansion a faint murmur or "breath sound" is simultaneously audible, which gains in intensity while the "râles" become smaller and higher pitched and finally disappear, in their last and smallest stage giving a typical representation of the familiar crepitant râle. After the disappearance of the "râles" the murmur is more distinct, and is now higher pitched than when first detected. The lungs are pretty well distended by this time, further distention raising the "inspiratory" or expanding sound still higher. Having reached a normal state of distention, the lungs can be made to expand and relax at will, still being maintained at a fairly tense level—at least sufficiently tense to avoid the production of "râles." It is at this stage that the mechanism of normal respiratory sounds is to be studied. By regulating the ingress and egress of air one can make use of a constant rate of air flow, and if normal conditions are imitated as carefully as can be done in this crude way, one hears a fairly loud "inspiratory" or expanding sound, distinct, even if the stethoscope is separated from the lung by a layer of air, somewhat higher pitched and less muffled than the sound we are familiar with over the chest surface, but in other respects very closely simulating it, while during "expiration" or relaxation of the lung may be heard coming from the rubber tube and not from the lung itself a much fainter, lower pitched sound, indistinguishable from the normal expiratory murmur. Overlaying such a lung with a piece of liver lowers the pitch of inspiration and makes the sound more faint and muffled—identical, in fact, with that often encountered over a normal chest, while the expiratory murmur becomes still fainter or disappears. The same differences are noticed over the lung of a breathing animal, first, with a portion of chest-wall removed, leaving a layer only sufficient to prevent collapse of the lung, and then with the chest-wall replaced. Of course, the pitch of the "inspiratory" sound will depend partly on the rate of the movements of the air.

The explanation which we support for the mode of production of the inspiratory sounds heard in these experiments and under normal conditions is practically that offered by Laennec and Skoda, and more clearly presented by Bondet, namely, that they are due to the air passing into the respiratory dilatations distal to the terminal bronchi, or, as Bondet expresses it, they are due to the passage of air from smaller to larger spaces. It seems to us that the conditions are favorable to effecting the familiar results, and no other explanation seems to be supported by as convincing evidence.

To refer briefly to the general structure of the pulmonary architecture, we find, according to Miller, that the terminal bronchus (0.4 mm. in diameter in the adult human being) continues into the vestibule, which opens into a number of atria (0.285 mm. in diameter), which in turn open by means of a number of air-sac passages (0.143 mm. in diameter) into corresponding air-sacs (averaging 0.412 mm. in diameter), which are beset peripherally with still smaller air-cells. The terminal bronchi also may have coming off from their walls atria with air-sacs and air-cells.

In order that the various external surfaces of these structures may come in contact with other similar structures and leave no space unoccupied, their external conformation naturally assumes a great variety of shapes, and usually presents a number of more or less flattened surfaces. But this does not prevent the occurrence of various relatively constricted and relatively dilated portions of the terminal air-bearing portions of the lung. According to Keith, the essential expansile parts of the lungs are the various spaces between the bronchi and the air-cells. He states that the air-cells, though widening during expansion, actually become more shallow. If the pulmonary or vesicular inspiratory murmur is produced distal to the bronchioles, the most likely place, or the most important place in the parenchymatous structure would seem to be where the narrow air-sac passage widens out into the considerably larger air-sac, which itself becomes enlarged by its surrounding air-cells.

This state of affairs, as far as the inspiratory murmur is concerned, seems amply illustrated by studying the behavior of a balloon during expansion. If one attaches to one end of a rubber tube long enough to exclude sounds coming from its opposite end the neck of a properly fitting balloon, and then inflates this balloon, and while still inflated attaches in similar fashion a balloon to the opposite end of the long tube, he can study the sounds over one balloon by alternately applying and relaxing pressure upon the other balloon. The balloon listened to should be under tension, which may be of any moderate degree. If it is then made to expand and contract at an equal rate, the expansion sound is much louder and higher pitched, suggesting the vesicular inspiratory murmur, the contraction sound being much fainter and lower pitched, and very suggestive of vesicular expiration, though the latter is probably a tubal sound. The pitch of the expansion sound will depend on the rate at which the air is moving, and on the tension and size of the balloon and the diameter of the opening. The contraction sound seems affected particularly by the rate of flow of the air. The sounds can be studied with the balloon either in the air or in water, in the latter case the tube itself being kept out of the water.

The contracting balloon is not a fair test of what occurs during expiration, because it is difficult to exclude the sound made as the air comes in contact with the sectional surface of the rubber tube inside the neck of the balloon. A simple representation of what apparently occurs during respiration may be found in an ordinary straight medicine-dropper, except here the walls are stationary. If one blows into the small opening, a very distinct sound is produced as the narrow portion expands into the wider portion, whereas if the air flows in the opposite direction, little or no sound is occasioned by the passage of air from the larger portion to the narrower. The sounds produced as air passes from a narrower to a wider channel have been explained in one or both of two ways,—either by the direct impact of the air against the walls of the first portion of the larger part of the canal, or by suction on this area, as described by Sahli for fluid murmurs arising under similar circumstances. Less sound is produced as the air-stream passes from the larger to the smaller tube, because less of the wall is involved in the vibrations, so that waves of smaller amplitude are engendered.

Can we apply results obtained in so large a structure as a balloon to a microscopical structure like an air-sac, which evidently could not alone produce vibrations of sufficient amplitude to be audible? Geigel tried to bridge this difficulty of the minuteness of the ultimate pulmonary structure by assuming that thousands of "Lungvesikeln" individually incapable of producing a sound might, by acting synchronously, give rise to a sound, however brief, and that this very brief sound, followed by other very brief sounds without any interval appreciable by the ear, might give rise to the continuous inspiratory murmur as we know it. Not only, however, does this rather complicated explanation seem to us unnecessary, but it in part seems erroneous, for it takes for granted that as long as the potentiality for sound production remains in any portion of the lung, it must still possess unexpanded vesicles. This means that all the sound produced in addition to that heard in quiet inspiration must be due to unexpanded vesicles—in other words, that even a considerably distended portion of lung must contain unexpanded vesicles or air-sacs if it is to produce further sound.

Only the briefest reference is necessary to the fact that the normal lung even at the end of quiet expiration is still under considerable tension, and that its bulk at this time becomes during quiet inspiration increased one-sixth to one-fourth, or may be increased during full inspiration to two-thirds, or may be actually doubled during full inspiration. This is a much greater relative increase than we find necessary in the case of the balloon for it to give a very distinct expansile sound.

Our conception of the mechanism of the inspiratory vesicular murmur is this: Even at the end of quiet expiration the air-sacs are considerably dilated and under tension, and most of them continue enlarging during the whole inspiratory act, even if it is forced. The degree of air impact or of suction exerted on the walls of the air-sac as the air passes into the larger space is sufficient to throw these walls into vibration. At the same time numbers of other air-sacs are being subjected to the same treatment, and even air-sacs immediately adjacent are similarly affected. Now instead of a balloon with a part of its walls set in vibration, imagine a portion of lung of the same size expanding at the same rate. The amount of vibratory energy exerted in the latter instance may be less concentrated, but may actually total a larger quantity of energy, even if more distributed. Instead of the balloon alone, we have, as it were, the balloon divided up into numerous small compartments whose walls are made of the finest membranous structure and connect with one another. According to the number of air-sacs present will be the number of regions where individual vibrations are instituted. The total effect of all this energy expended on the intermingled membranous structures can readily be conceived to be of sufficient intensity to result in appreciable sound, because we have thousands of regions where minute sound vibrations are acting in unison, or so nearly in unison that the ear cannot detect any intermission.

The Expiratory Pulmonary (Not Vesicular (?)) Murmur.—If the expiratory murmur or any part of it ever arises normally in the lungs, instead of in the upper respiratory tract, where all our evidence suggests that it originates, the natural place to expect to find its source would be where the air passes through the same spaces that produce the inspiratory murmur, only in the reverse direction, that is, from the atria or other relatively wide areas to the smaller proximal areas. Undoubtedly vibrations are produced in this way, but are apparently too feeble to be appreciated, or are masked by the louder sounds coming from the upper respiratory tract.

Effect on the Respiratory Sounds of the Passage of Vibrations From Lung Through the Chest-wall.—Effect on Intensity.—No new elements have to be introduced in speaking of the reduction of the respiratory murmur as it passes from lung to chest surface beyond what has already been said regarding intensity as dealt with under Vocal Resonance. The sounds have to traverse the same routes as do the voice sounds in passing through the lung structure and the chest-wall. The respiratory sounds pass through lung (except those arising just beneath the lung surface), from lung to chest-wall, and through the chest-wall, suffering the loss in intensity that naturally goes with such a passage, the associated factors of which have been already discussed. These are, chiefly, first, the loss from reflection of tense membranes in the lung. As the vibrations of these membranes initiate the sounds they may play considerable part in conduction as well as in reflection, though to a much less degree. Secondly, the loss due to the reflection as sounds pass from the air in the lung to the chest-wall.

The Pitch and Quality of the Normal Pulmonary Murmur.—As contrasted with the sounds heard directly at the lung surface, those over the chest-wall apparently are lower pitched and more distant, but otherwise present no great difference. The sound being very distinctly weaker over the chest-wall than over the lung, renders it difficult for a person whose ear is not trained in scientific acoustics to thoroughly differentiate the changes in intensity over the chest as compared to those over the lung surface from those of pitch and quality. There are not demonstrable any factors that might unequally affect different vibrations, such as reënforcement or interference, so that any changes that take place in pitch and quality are apparently due to the diminution or abolition of the weaker vibrations.

In estimating the loss in intensity due to the transfer of sounds from lung to chest-wall, account must be made of the loss suffered in the passage of sounds from the chest-wall to the stethoscope, which is greater than the loss sustained as the sound passes from the lung to the stethoscope.

BRONCHIAL BREATHING.

It may be a matter of surprise to those who have absorbed and accepted some very definite teaching as to the mode of production of bronchial breathing to learn that even to-day there exists not only wide diversity, but also great uncertainty, of opinion regarding the mechanism of bronchial breathing. This cannot be better exemplified than by Geigel's concluding statement to his discussion of bronchial breathing in his most excellent "Leitfaden der diagnostischen Akustik," "Ich stehe aber nicht an, dieses ganze Kapitel meines Leitfadens für das schwächste von allen zu halten."

The literature on the subject of the sources of bronchial breathing in consolidation gives us almost as wide a choice of sites of origin as that dealing with vesicular breathing, and covers a large part of the respiratory tract.

Laennec thought the sources of pathological bronchial breathing were the large and small bronchi, the intensity of the sounds being due to the improved conditions for conduction. Skoda believed the sounds originated in the respiration of the trachea and larger bronchi, and that these sounds, being consonated by the air in the bronchial tubes, attained sufficient intensity to be heard with the familiar intensity. Austin Flint writes: "Regarding, then, the bronchial respiration as consisting of transmitted sounds, they are produced within the trachea, the primary bronchi, and probably also within the subdivisions of the latter, and are conducted by the air in the tubes and the solidified lung to the ear of the auscultator." Gee states, "bronchial breathing is the glottidean sound as heard in the larger bronchi." Aufrecht attributed it to the passage of the respiratory current across the mouth of the bronchus supplying the consolidated area. An actual current of air within the affected tubes, and (Andral) an increase of pressure of the air within and upon the bronchial tubes, due to the obstruction to the entrance of air into the air-cells, are also among the many views that have been held regarding the sources and mode of production of pathological bronchial breathing.

As a proper introduction to this subject one must have some general idea of what the character of the bronchial breathing of disease is. To the clinician it is familiar as the breathing ordinarily associated with consolidation. Austin Flint has described it as analogous to the sounds heard over the trachea, his description of the latter sounds having been given when we were speaking of tracheal breathing. The comparison is very apt to the extent that his description of tracheal breathing presents clearly some of the points of contrast between bronchial and vesicular breathing. A better idea of the bronchial breathing over solidified lung can be obtained, at least as applied to many of the cases of consolidation, by listening over the trachea while the mouth of the bell of the stethoscope contains a thin piece of cork or other suitable material. The average breathing heard over consolidation varies to a certain degree, and in extreme cases such breathing may be quite different from the usual bronchial breathing, at times being even cavernous if the tracheal breathing is cavernous. Austin Flint recognized that for bronchial as well as tracheal respiration the pitch might vary. Our attempt, however, will not be primarily to determine the sources of any special variety of bronchial breathing, but the sources of sound heard over complete consolidation during respiration, and, secondarily, as far as possible, to assign to each source its due proportion, and to determine to some extent what factors may modify the sounds under different circumstances. The subject is somewhat simplified by keeping clearly in mind the distinction between the intensity of bronchial breathing and its other characteristics, for it may be very feeble as well as loud, and quite distinct when the vocal resonance is actually diminished, though ordinarily it is associated with an increase in vocal resonance. And we should approach the subject without any preconceived notion as to whether the bronchial breathing must be due to sounds that would be audible in health if the conditions for sound conduction in health were sufficiently favorable.

Perhaps the simplest way to classify the different possible sources of pathological bronchial breathing is into two main groups,—(1) Those sources existing in the healthy portion of the respiratory tract above and below the bronchus going to the affected area, and independent of it, and (2), those arising as a result of the consolidation. The state of affairs may be represented in its simplest form by a T-glass tube, the lower end of the vertical limb being closed with thin membrane, over which the stethoscope is placed, while a current of air is directed through the horizontal portion. The sources of sound as heard must be investigated for purposes of analysis into the sources to the right and left of the vertical limb of the T-glass tube and independent of it, and those due to the presence of the vertical limb of the T-glass tube.

The Sounds Present in the Healthy Portion of the Respiratory Tract Above and Below the Bronchus of the Consolidated Area.—The bronchus supplying the consolidated lung communicates through its mouth with the respiratory tract above and below, and is, therefore, a recipient of sounds from these sources. In other words, it communicates with all kinds of possible sound sources existing in the normal respiratory tract, from the vesicles to the nose and mouth. This holds true whether a whole lung or a part of a lung is affected, and whether one or another portion of lung is involved. It may also be well to insist that the sounds produced at these different sources external to the consolidation may affect the sounds over the consolidation, even if the sounds have to move in an opposite direction from the respiratory current, as well as if in the same direction. It may also be accepted that any increase in rate of the respiratory current will be felt throughout the extent of the respiratory passages, and will not cause any known disproportionate increase in intensity at any one place, unless possibly at the vocal cords, where the glottis may be distinctly more narrowed during forced than quiet expiration.

In discussing the normal respiratory sounds we concluded that the most intense sounds in the upper respiratory tract arose in the trachea or larynx and above them, that the most intense sounds in the lower respiratory tract arose in or near the vesicles, while the remaining portion of the tract, that is, the tubal structure presenting a smooth and even interior, we believed could produce, at best, very much weaker sounds. The air currents in the larger and smaller bronchi, resembling somewhat the blood-currents in the vascular system, move along without producing any sound appreciable by ordinary clinical methods. We are interested first, then, in the effect the normal respiratory sounds in the upper and in the lower respiratory tracts may have on the sounds heard over consolidation.

The Sounds Produced in the Upper Respiratory Tract.—Except for the possible effect that the vesicular murmur may have on the inspiratory sounds heard over the trachea,—and this we have seen is only a minor factor in most cases,—the sound heard over the trachea may be considered to be produced in the upper respiratory passages. It is definitely established that the sounds produced in the upper respiratory passages in many cases are a marked factor in the production of the sound we know as pathological bronchial breathing. Bondet's classic experiment demonstrated that marked changes in the breath sounds heard over a consolidated area in a horse could be produced by removing the larynx and by various manipulations of the trachea, the changes being more marked than could be accounted for by simply a change in the rate of respiration. The degree of similarity often existing between the characteristics of the tracheal and the pathological breath sounds is very suggestive of a common origin for much of the sound. The fairly close resemblance between the more complicated whispered sounds as heard over the trachea and the solid lung corroborate the other evidences that the two sounds have at least to some extent common sources of origin. When one considers the intensity of the sounds produced in the upper respiratory tract, as over the trachea, and the relatively favorable conditions for sound transmission when the lung is consolidated, it is reasonable to associate the sounds heard in the latter case with those produced in the upper respiratory passages. In discussing vocal resonance and whispered sounds, ample evidence was furnished to show that sounds as loud as the breath sounds within the trachea can be plainly transmitted through solid lung, for example, in the case of the fetal calf, in which sounds of moderate intensity introduced by means of a T-glass tube, the vertical limb being connected by a rubber tube with the trachea, while some one blows into the horizontal portion, can be heard with great distinctness at the surface of the chest and even through more tissue overlying it, though the original sounds entering the trachea are not louder than those within the human trachea produced in the upper respiratory tract. The fact that the breath sounds over solid lung may present distinct differences from those heard over the trachea, is not in itself evidence sufficient to militate against a source in the upper respiratory tract for the bronchial breathing of consolidation, because the spoken and whispered sounds that arise in the upper respiratory tract may be quite different and have many of the characteristics of bronchial breathing when heard over consolidation.

The Sounds Produced in the Lower Respiratory Tract.—Granting, then, that the upper respiratory tract may exert a marked influence on the breath sounds heard over a consolidated area,—and there are other ways of demonstrating this, to which we will refer later,—how does this effect of the upper respiratory tract compare with that produced by the sounds originated in the lower respiratory tract, that is, in or near the vesicles?

This can be settled pretty readily as far as the expiratory sounds produced in the lower respiratory tract are concerned, for these are so feeble, even during forced expiration, if, indeed, they are produced at all in the lower respiratory tract, that they cannot compete with the sounds produced in the upper respiratory tract. Thus when a tube is connected to a trachea supplying expanding and contracting lungs, there will be heard coming through the tube walls a loud inspiratory sound, but little or no expiratory sound, provided the tube is long enough to eliminate the sound at its free or distal opening. This subject has been dealt with sufficiently in the section on the Vesicular Murmur to make unnecessary any further treatment here.

The Effect on Bronchial Breathing of the Inspiratory Vesicular Murmur.—This murmur, as we have seen, is quite a loud sound—much more so than the expiratory pulmonary sound. Its intensity as audible over the chest is familiar to every one, and we have shown that at the actual lung surface the intensity is much more marked than at the external chest surface. In contrasting it with the inspiratory sound produced in the upper respiratory tract, we wish to know which is the louder at its seat of origin, and, of more importance, their relative intensity on reaching the mouth of the bronchus supplying the consolidated area. That the vesicular murmur can reach as far as the solid lung, and even to the trachea and beyond, has already been shown, provided the sound in the upper respiratory tract is not sufficiently loud to overwhelm it. We have stated our belief that at least in some cases the sound heard over the trachea is modified by the vesicular inspiration. Aufrecht claims to have heard vesicular breathing over a solid lung while the healthy portion was being inflated through the trachea. As one approaches the periphery of the lung, thus moving toward the site of production of the vesicular murmur, and away from that of the murmur produced in the upper respiratory tract, the conditions for hearing the former become more favorable, and for hearing the latter less so. It would thus seem that in small peripheral consolidations the inspiratory vesicular element might be especially in evidence.

Of course, some of the intensity of the vesicular sound is lost by the time those bronchi larger than the terminal bronchi receive the vibrations, because they have had to pass through either the smallest bronchi or across other vesicles, or through bronchial walls, but even making this allowance, a very considerable amount of sound coming from the vesicles remains in the bronchi. If one listens to the sounds over a tube connected with the interior of a trachea supplying the lungs of a living animal, very distinct inspiratory sounds will be heard, and sounds of very considerable intensity will have to be produced in the tube to altogether abolish the inspiratory vesicular sound.

The Part Played by the Consolidated Area in the Production of Bronchial Breathing.—In addition to the marked changes in the factors of transmission associated with the solid as compared to the normal lung, it is desirable to know how much of the sound known as bronchial breathing results from the consolidated area itself, as distinct from the sounds coming to it from other and normal regions. Does the consolidated area alter the sounds arising elsewhere, and is it responsible for the production of any new sounds, and if so, where and how are these effects brought about? In attempting to determine this, one naturally considers, first, the tubal structure, and, secondly, the structures external to the bronchi.

Penetrating the consolidated area is a single bronchus, to take the simplest illustration, which divides and subdivides, as in the normal lung, until the smallest bronchi are reached. These, however, no longer continue into the air-spaces beyond, for they have become filled with a pneumonic or other exudate, which extends a variable distance up the terminal bronchioles. With this change in the vesicles they cease to expand and contract, so that a current of air into and out of the bronchi from this source is eliminated, though it has been a favorite theory with many that a bronchial respiration within the affected area may exert a distinct effect on the final sounds. On account of the relative rigidity of the bronchial walls when encased in solid material, there can be little motion of air within them transmitted from those air movements occurring near the mouth of the bronchus opening into the respiratory currents, which operate in the healthy portion of lung.

Considering, first, the effect these bronchial spaces may have on sounds coming from without, and omitting any effect the respiratory current may have, we may conclude, from what has already been said about the voice and whispered and other composite sounds coming to the consolidated area, that the air in the bronchi will reënforce some of these sounds, will diminish others, and will leave some unaffected, all depending on the length and manner of division and other conditions associated with the bronchi, and depending also on the character of the sounds received by them. Thus, if the bronchi were very short, the sound within them might be higher pitched, and if long, would probably be lower pitched, than the sound prior to its entrance into the consolidated area. With changes in pitch, qualitative changes might also arise. Moreover, it is conceivable that those vibrations reaching the smaller bronchi may, on account of the size of these bronchi, be travelling at a rate sufficiently different from those in the larger bronchi, and from the vibrations that have already escaped from the bronchi, to have a decided influence on the terminal sound, the same conditions which we thought might also be present in relation to spoken and whispered sounds. Clinically, it appears that the more extensive the consolidation, and the larger the bronchi that are connected by solid tissue to the chest-wall, the more closely the sounds approach those existing in the large bronchi and trachea, not alone in intensity, but in pitch and quality. In addition to excluding any movement of air in the bronchi of the consolidated area arising from bronchial expansion, we may also regard as negligible any sounds arising in the bronchi due to friction on their walls of the air moving up and down these bronchi as a result of the movements of air at and near the opening of the "parent" bronchus of the consolidated area.

We have left to consider, then, those sounds that might arise at and near the opening of the bronchus of the solid lung into the normal respiratory current. The conditions are those of air moving to and fro through a tube and across a communicating tube, the walls of which latter tube are stationary and do not themselves take an active part in the movement of the air. The conditions in their simplest analysis are those of air moving to and fro through the horizontal limb of a T-glass tube, the lower end of the vertical limb being excluded from the surrounding air, either by a piece of rubber tissue or by communicating with a rubber tube closed at its other end. Now, while conditions exist for the production of vibrations where the upper end of the vertical limb of the T-glass tube opens into the horizontal limbs, these vibrations will not possess much energy unless the air-current is much stronger than normal. Thus if one attaches long rubber tubes to the free ends of the horizontal portion of the T-glass tube, a current of air of considerable rapidity will be required to produce much of a sound at the lower closed end of the vertical limb of the T-glass tube. If one of the long rubber tubes just referred to is introduced into the trachea of a breathing rabbit, very little sound will be heard during expiration at the lower end of the vertical limb of the T-glass tube. (The tubes should be long to exclude sounds made at the ends not attached to the T-glass tube, and only expiration in the case of the rabbit should be observed because the inspiratory pulmonary sound would be audible unless the tubes were of very considerable length.)

The general notion is that the passage of air across the mouth of a tube tends to excite a sound of considerable intensity, and this is true as far as isolated tubes are concerned, with their mouths everywhere exposed to a blast of air, but true only to a very much less extent if the tube across the mouth of which the air is passing opens out into another tube conveying the air-current, but does not project into this current. In the former case the air impinges directly upon the margins of the tube, while in the latter case the tube margins form part of the wall of the tube conveying the air current. If one tube should actually project into the lumen of another tube containing an air-stream, then a very much louder sound would be produced. The same difference in intensity will be obtained if one blows first over a small opening in a rubber bulb, and then into the horizontal portion of a T-glass tube, the vertical limb entering, and fitting tightly into, the opening in the rubber bulb. So that while distinct vibrations are set up by the air in the T-glass tube, vibrations which can be observed to some extent by having the vertical limb filled with water, they do not possess much energy compared to vibrations coming to this tube from without.

The tubal arrangement at the mouth of a bronchus is not, however, quite as simple as that just outlined. Instead of an ordinary T-glass arrangement, we find two bronchi coming together to form a larger one, or to form, what amounts to the same thing, the trachea, this junction being in the shape of an inverted Y, and two smaller limbs coming together to form a larger one. A Y-glass tube possessing these general characteristics, that is, with two smaller tubes converging at an acute angle to form a larger one, is useful for studying some of the elementary factors at work. One of the smaller limbs is attached to a rubber tube closed at the other end, and this tube is listened to, representing the tubal structure of the consolidated area. The other smaller tube can be connected by rubber tubing with the mouth or with a trachea going to lungs inside the body of a living animal. To the free end of the largest limb of the Y-tube a rubber tube of larger size than the other rubber tubes is attached, long enough to eliminate the sound made at its free opening. It is of the utmost importance in using the Y-glass tube, as representative of the pulmonary tubal arrangement, that the air current passing from the large tube to one of the smaller ones should be introduced into the smaller tube by means of negative pressure, as is done under natural conditions by the lungs, and as can be imitated by drawing the air through the smaller tube into the mouth. If, instead, one should blow directly into the larger tube, very loud sounds would be set up in the tube ending blindly, sounds not produced in cases of consolidation.

With such an arrangement a very faint sound may be made as the air passes across the mouth of the tube terminating blindly at its other end, much as in the case of the T-glass tube. The pitch will vary somewhat with the angles it makes with the other two limbs. But a new element is found in this specially constructed Y-tube, an element existing also in the case of the bronchi, and that is the passage of the air to and fro between a smaller space, the space in one of the smaller tubes, and a larger space, the space formed by the junction of the two smaller tubes, and also the passage of air in the reverse direction. Under normal conditions the air passes back and forth between both smaller tubes and the larger tube, but if the air-current ceases in one of the smaller tubes, then the passage is either from a larger to a smaller space, or from a smaller to a larger space, which may have considerably different acoustic effects from the normal.

Bullar claims to have shown, with that rare apparatus of his which he termed an artificial thorax, in which he could expand and relax lungs at will while he listened to them, that if the lungs were dilating and contracting with the production of the usual sounds, and then one main bronchus was occluded, the inspiratory sound over the trachea became slightly altered, while the expiratory sound became much intensified. The sound produced under conditions like these was described by him as a sound materially affecting the sound heard over consolidation during expiration, and was attributed to the passage of air from a smaller space into the larger space formed by the junction of the two bronchi with the trachea.

This sound we have not been able to produce with lungs, perhaps because we could not maintain proper conditions outside the body. However, with a Y-glass tube having the vertical or lower limb larger than the two upper limbs, and attaching sufficiently long rubber tubes to all the three limbs, and occluding the rubber tube supplying one of the smaller limbs, while the mouth of a person inspiring and expiring at a fairly even rate grasps the tube supplying the other of the smaller limbs, one will hear, on listening over the tube ending blindly, decidedly louder sounds during the passage of air in both directions than were heard with a similarly arranged T-glass tube in which all the limbs were of the same caliber, the rate of the flow remaining constant. We have sometimes obtained louder sounds as the air passed from the smaller glass tube to the larger one than from the larger to the smaller, but not always; in fact, at times the louder sounds were obtained with the air passing in the reverse direction. It is, of course, essential that in trying to determine the intensity of the sounds at the mouth of one limb of a Y-glass tube, or at the mouth of a bronchus entering a consolidated area, that sounds produced elsewhere in the tubes be eliminated.

Summary.—Our studies with tubes used in the manner described inclines us to believe that the sounds produced at and near the mouth of a bronchus of a consolidated area play a relatively unimportant part in the formation of bronchial breathing, as compared to those arising external to the consolidation. In trying to obtain light on this subject from clinical experience we are naturally impressed with the way in which whispering sounds are transmitted from the upper respiratory tract when the respiratory current in the lower tract is too feeble to add much to the sounds. There is no question that the upper respiratory tract plays an important part in the formation of the bronchial breathing. We have already expressed our views in regard to the importance of the normal inspiratory vesicular murmur in contributing to the bronchial sound during inspiration. The sounds produced at and near the mouth of the bronchus appear to be the least important. The effect upon the sounds arising external to the consolidated area by the columns of air within the bronchi of the solid lung deserves attention.

The peculiar characteristics of bronchial breathing seem to be produced in much the same manner as those of the spoken and whispered sounds heard over consolidation; or, as the breathing and spoken and whispered sounds over excavation. That is, it appears that all these sounds are very largely tracheal sounds (the sounds present in the trachea), modified by the shape and size of the air-spaces below the trachea, and that the sounds originating *de novo* in the lower respiratory tract are much less important, some exception being made for the part the inspiratory vesicular murmur plays when inspiratory sounds are being auscultated.

The Intensity of the Bronchial Breathing.—As the sounds within the bronchi of a consolidated area proceed toward the external chest-wall, their intensity will depend largely on the same factors that influence the spoken and whispered sounds when traversing the same routes, namely, reflection, which affects the vibrations as they pass from within the bronchi to the bronchial walls, and diffusion, which takes place between the bronchi and the external chest surface, and will be influenced by these factors in much the same way and to much the same extent.

The pitch and quality of the bronchial breathing depend on factors which have been roughly indicated. These factors are, to a great extent, the same as those affecting the spoken and whispered sounds. It is, therefore, readily understood why some of the distinctly "bronchial" characteristics of bronchial breathing should also be present in spoken and whispered bronchophony.

If the mechanism of bronchial breathing as here presented is correct, the question may be offered whether the term "bronchial" as used in this connection has any recommendation except that of long usage. It is apt to convey the idea that the sound heard over consolidation is produced by the friction of the air against the bronchial walls either of the normal or diseased lung, which is, of course, untenable. If one understands by "bronchial" an anatomical region, that situated over the larger bronchi posteriorly, and if one means by "breathing" a sound produced by respiration, and applies the term "bronchial breathing" to any sound like that heard normally over the larger bronchi during respiration, thus using the term as simply descriptive of its character and not indicative of its origin in consolidation, it may be as well to retain this term as to introduce a new one.* The term "breath sound" has certain advantages over that of "breathing," as is also the case with amphoric and cavernous "breath sound" as compared with amphoric and cavernous "breathing."

Bronchial Breathing Over Pleural Effusions.—Bronchial breathing when audible in cases of pleural effusion is to a great extent produced in practically the same way as in simple consolidation. Whether in the case of effusion the lung is solid, or simply collapsed, while still air bearing, and if the external pressure on the collapsed lung is sufficient to prevent expansion of the lung during inspiration, the vesicular sound is eliminated within the affected lung, and the only sounds remaining are those described as arising in the upper respiratory passages and in the lungs of a case of simple consolidation, and these sounds will be heard if the conditions for transmission are satisfactory.

Not only are the original sounds at their sources much the same in cases of pleural effusion as in those of consolidation, but the conditions for modifying these sounds within the tubal structure of the collapsed lung are, generally speaking, based on the same factors as affect the sounds produced in cases of consolidation after they enter the tubes within the solid lung. These factors are concerned in the reënforcement or diminution of some of the vibrations forming a part of the whole sound. But inasmuch as the bronchi within the collapsed lung may present differences in caliber, length, and other particulars from those of the solid lung, it is conceivable that different effects might be obtained in the two cases. Thus, with the relatively shorter bronchi of the collapsed lung higher pitched sounds might be reënforced than in the case of the longer bronchi of the solid lung. It is through the reënforcement and diminution of some of the vibrations that it is conceivable may partly lie the explanation for the presence of bronchial breathing over an effusion when the voice sounds are diminished.

---

* True bronchial breathing, however, occurs rarely if ever over the normal chest.

CAVERNOUS AND AMPHORIC BREATHING.

The literature on the mechanism of cavernous breathing is to a great extent unsatisfactory. According to Laennec, it is the sound "produced by inspiration and expiration in an excavation," instead of by the movement of the air in and out of the bronchi, as in cases of consolidation, which is his explanation for pathological bronchial breathing. Skoda denied the existence of a cavernous as distinct from a bronchial breathing, and his teaching has borne unprofitable fruit in Germany. According to Flint, the inspiratory sound is lower in pitch than in bronchial breathing, the intensity of the expiratory sound in cavernous breathing is more feeble than the inspiratory, its duration is less variable, and its pitch is lower than that of inspiration, while in quality both sounds are blowing in character as compared to the tubular respiration of consolidation. His explanation for the sounds was that of Laennec's, the movements of air in and out of the cavity. Walshe believed the mechanism of cavernous breathing to be of at least two kinds, one being that described by Laennec, which depends on a free entrance and exit of air into and out of the cavity. "If," to quote his second explanation, "from rigidity of the thoracic walls, or other physical impediments, the cavity itself can scarcely be supposed the seat of active movement of the air, the cavernous quality is probably that of the neighboring bronchial breathing modified and reënforced within the excavation." It is strange how little impression this second explanation has made.

Much of what we have to say on this subject has already been presented. In searching for the source of the breath sounds heard over excavations we may group the different sites for consideration in two main divisions —(1) Those external to the cavity, and (2) those associated directly with it. In the first division we have the same sites as in consolidation; in the second, we have those associated with the cavity instead of with the bronchi of a consolidated area. As far as we can see it, the mechanism is much the same in the two cases, except that a cavity replaces bronchial tubes. The sounds made at the mouth of the particular bronchus into which the cavity opens apparently have no more importance than if consolidation replaced the excavation. The sources of sound mainly responsible for bronchial breathing we traced chiefly to the upper respiratory tract, and, during inspiration, also to the inspiratory vesicular murmur, and these sounds in the upper and lower respiratory tracts are as loud when there is excavation as when there is consolidation, and what is to prevent their transmission with quite as much intensity into a cavity as into a consolidated area? That the current of air in and out of the cavity, or within the bronchi surrounded by consolidation, is not essential to the production of sounds having the characteristics of pitch and quality found over excavation or consolidation, is indicated by the fact, already alluded to, that during spoken or whispered speech, when the rate of the air-current in the lower respiratory tract is much less than during respiration, especially when forced, one still may obtain much the same pitch and quality of sounds as are associated with the breath sounds in either excavation or consolidation. If there were no other sufficient sources of sound outside of a cavity to give sounds of the intensity we hear at the chest surface, there would, perhaps, be more excuse for extended investigations regarding the motions of air to and from a cavity as possibly producing the sounds. To produce a sound of any magnitude in this way considerable motion of the cavity walls would be required—more than seems possible under the circumstances. The chest-wall near a cavity is usually expanding too little to introduce much air into this portion of the chest, and around the cavity the surrounding involved tissue and the chest-wall, if the latter is close to the cavity, are usually sufficient to interfere with any free expansion of the cavity walls. If one listens over a rubber bulb having a single opening which is connected with a rubber tube fitting tightly into the mouth of the opening into the bulb, the tube being long enough to exclude most of the sounds formed external to the rubber bulb, a very extensive degree of expansion and contraction of the bulb walls is necessary to produce a sound of any considerable intensity as heard over the surface of the bulb.

In speaking of cavernous and amphoric spoken and whispered sounds, we indicated by the use of tubes and "cavities" how the mechanism of cavity sounds might be represented in their most simple form, and how much of a part sounds outside the tubes and cavities can play. If one blows through the horizontal limb of a T-glass tube, the vertical limb of which is inserted into a rubber tube closed at the other end, or is inserted into the single opening of a rubber bulb, the sounds made at the free end of the horizontal portion of the T-glass tube are heard over the rubber tube or bulb, modified chiefly by the size and shape of the air-containing space, of either the tube or bulb, the sounds over the bulb being lower pitched than over the tube if both have the same long diameter. Another example of the influence of a tube or cavity on external sounds can be obtained as follows: To one end of the horizontal limb of a T-glass tube a rubber tube of some length is attached, and sufficient moisture allowed to collect in it so that a current of air stirs up imitation râles in the tube. Now, if a rubber tube is attached to the vertical limb of the T-glass tube and closed at its lower end, or if a rubber bulb is attached to the vertical limb of the T-glass tube, the "râles" as heard over the tube will have an entirely different pitch from those heard over the rubber bulb, being higher pitched over the tube and lower pitched over the bulb, if both have the same vertical diameter. Incidentally, this is the way in which we believe many of the râles audible over consolidation and excavation are produced—not actually within the bronchi or cavities, but transmitted from without into the cavities, and there modified to give some of the characteristics ordinarily associated with râles heard over solid lungs or cavities.

We are more interested in establishing the original source of the sounds heard over excavation than in discussing the particular factors at work in producing the sound characteristics that depend entirely on the cavity. It is our contention that the sounds heard over an excavation are produced *originally* outside of the cavity in most cases, and are conveyed to the cavity by the bronchus into which the cavity opens. In the same way the spoken and whispered sounds audible over a cavity have their *original* sites of production altogether outside the cavity.

In what way and to what extent the cavity affects the sound introduced into it seems less to require consideration here, as the factors operative under these conditions have been to a great extent ably presented by Geigel and others. In our opinion the character of the cavity walls in different cases, as far as rigidity or reflective capacity is concerned, is sufficiently uniform to be regarded for general purposes as a constant feature. Whether a cavity is surrounded by solid or fibroid lung, or whether it has a paper-like covering attached to the chest-wall, a good deal of rigidity in the surrounding structures is usually present. The main effects on the sound that are due to the cavity depend, we believe, for the most part, upon the size and shape of the cavity and of the bronchus into which it opens, and upon the mutual arrangement of the bronchus and cavity. The bronchus and cavity may be considered as two different spaces affecting the sounds entering them. The more marked and abrupt the angle formed by the junction of the bronchus with the cavity, the more distinct are the characteristics of the sounds in each, while the more gradually and evenly the bronchus widens out into the cavity space, the more does the one space partake of the nature of the other space and the more nearly does the condition approach that of a single space.

Summary.—According to our conception, then, the sounds heard over an excavation are not, whether breath sounds or spoken sounds or whispered sounds, for the most part, the result *primarily* of sound vibrations arising within the cavity, but are sounds arising external to the cavity, being later modified through the reënforcement or diminution of some of the original vibrations to give us the sounds which we hear. No new air currents exist with excavation that were not present in the solid lung, the differences in the mechanism of the sounds in the two cases depending on the differences in size and shape of the space or spaces containing air that is quiescent.

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DIAGRAMMATIC REPRESENTATION OF HOW REFLECTION AND DIFFUSION, THE MOST IMPORTANT FACTORS THAT DIMINISH SOUNDS ON THEIR WAY THROUGH THE CHEST, MAY OPERATE IN SOME OF THE PULMONARY AND PLEURAL CONDITIONS.

Continuous lines indicate surfaces of special reflection; broken lines indicate the surfaces of no special reflection except those common to all the conditions, namely, the outer chest surface and the internal bronchial surface. Fluid-tissue junctions, and the junctions between relaxed lungs and air, are not specially indicated, because the changes in density at these junctions are not specially great.

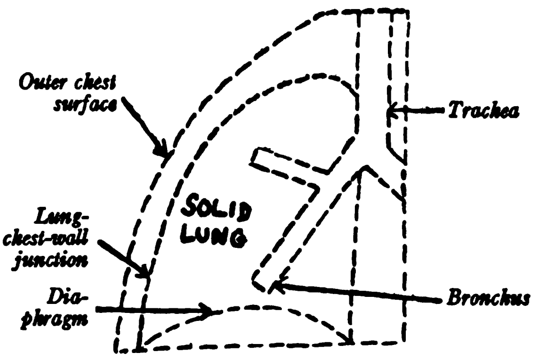

FIG. 1.—Solid lung. No special reflection after the sounds enter the bronchial walls. More sound retained within the bronchi than normally. Diffusion an important factor, but no special diffusion present that is absent in other conditions. Vocal resonance increased.

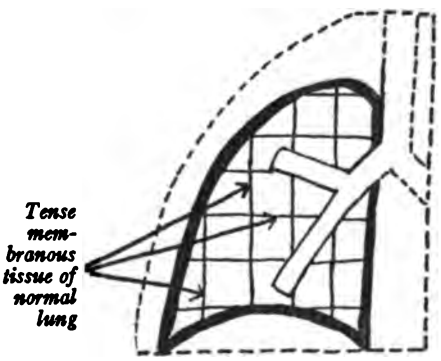

FIG. 2.—Normal lung. Reflection at lung-chest-wall junction, at junction of tense membranous tissues of lung with air, and at surface of contact between bronchi and surrounding air in the vesicles (a somewhat questionable factor). Diffusion much as in Fig. 1. Vocal resonance normal.

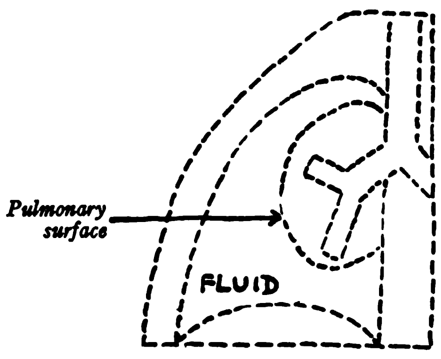

FIG. 3.—Pleural effusion. Lung solid. No special reflection. Special diffusion between lung and chest-wall. Vocal resonance may be increased.

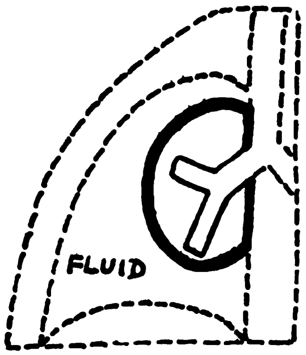

FIG. 4.—Pleural effusion. Lung air-bearing, but membranous tissue relaxed. Special reflection at lung-fluid junction, and, to some extent, at surface of contact between bronchi and surrounding intravesicular air. Special diffusion between lung and chest-wall. Vocal resonance diminished.

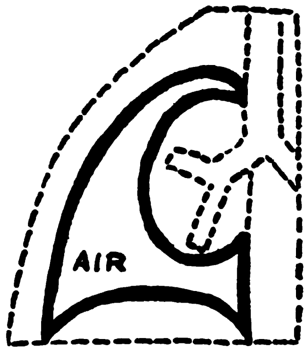

FIG. 5.—Pneumothorax. Lung solid. Special reflection at air-chest-wall junction and lung-air junction. Special diffusion between lung and chest-wall. Vocal resonance diminished or absent.

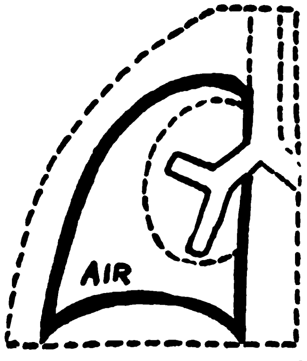

FIG. 6.—Pneumothorax. Lung air-bearing. Special reflection at air-chest-wall junction, and, to some extent, at outer bronchial surface. Special diffusion between lung and chest-wall. Vocal resonance diminished.

SUMMARY.

The preceding pages deal with some of the major acoustic factors operative in the production and transmission of sounds heard over the lungs in a number of representative normal and pathological conditions. Some of the elemental facts which we have endeavored to establish may be briefly summarized as follows:

The Origin Of Sounds.—Vesicular Inspiration.—The normal vesicular inspiratory sound arises within the lungs, as the air passes from the terminations of the smallest bronchi or their continuations into larger spaces beyond. Ordinarily it is entirely independent of sounds produced in the upper respiratory tract.

Vesicular or pulmonary expiration arises partly, if not wholly, in the upper respiratory tract.

Bronchial Breathing.—Both inspiration and expiration originate largely in the upper respiratory tract. Both may be modified, probably rather slightly, by the passage of the air between the normal lung below the affected area and the regions above the affected area, that is, by the passage of air in the neighborhood of the mouth of the bronchus supplying the involved lung. During inspiration the inspiratory vesicular murmur may at times contribute to the sound. The tubal structure in the solid or compressed lung, though giving rise to no distinctly new sounds, may decidedly affect those entering it from without.

Cavernous and Amphoric Breathing.—These sounds have their primary origin at much the same sites as those responsible for bronchial breathing, of which the upper respiratory tract furnishes the most important. But instead of simple bronchi in the affected area, we have a bronchus connected with an excavation, which arrangement modifies the sounds arising external to the excavation, without giving rise to entirely new and independent sounds. The movement of the air in and out of an excavation, as a producer of appreciable sound, is generally, if not always, a negligible factor.

The Transmission Of Sounds.—The chief factors tending to affect the intensity of sounds within the chest on their way to the periphery are diffusion and reflection, while, to a less extent,—usually very much less,—the factors of absorption, resonance, and, possibly, interference may operate.

Diffusion of sound is a constant process, finding its chief restriction within the air inclosed by the bronchi, in which the sound extends toward the periphery with comparatively little dilution. Diffusion is a much more important factor in the diminution of sounds within the chest than is generally recognized, often filling the rôle attributed to absorption or poor conduction.

Reflection of sound, as we shall employ the term, is effective in reducing sounds: (1) As they pass from the air within the normal vesicles to the surrounding tense membranes; and (2) where there is a marked change in the density of two media, such as is met with in the juxtaposition of air and tissue. The loss in intensity sustained by the sound in its passage between tissue and fluid is relatively slight—very much less, indeed, than is generally supposed.

Absorption of sound, that is, its disappearance as sound energy, though commonly accredited as a factor of great importance in the diminution of thoracic sounds, actually plays a very unimportant part. Some absorption of sound does occur, but to a very minor degree, as the sound passes between media of different densities, and as it comes in contact with the tense membranes in the lungs, and in its passage through the gaseous, liquid, and solid structures of the chest. But the major part of sound loss generally ascribed to absorption is due to the factors of diffusion and reflection, as we apply these terms.

Normal Lung.—The diminution of sounds on their way through the normal chest is due chiefly to the factors of diffusion and reflection. The latter acts particularly: (1) As the sound within the air in the bronchi comes in contact with the bronchial walls, especially of the larger bronchi; (2) as the sound passes from bronchial wall to the air in the surrounding vesicles; (3) as the sound comes in contact with the tense pulmonary membranes; and (4), as the sound passes from the air in the lung to the chest-wall.

Consolidation.—Apart from the marked loss in intensity of the sounds as they pass from within the bronchi to the bronchial walls, the chief loss of sound in consolidation as it passes to the periphery of the chest is due to diffusion. It is not due to absorption. One can readily see why the solid lung ordinarily gives louder sounds than the normal lung.

Pleural Effusion.—In cases with diminished or absent vocal resonance the chief source of sound loss after the vibrations have entered the fluid is due to diffusion, and not to absorption or reflection. Diminution of sound is impeded, and there may be an actual increase in vocal resonance when the lung, instead of being collapsed and air bearing, is actually solid, because there is comparatively little sound lost at the lung-fluid junction when the lung is solid, just the reverse of what occurs when the lung contains air.

Pneumothorax.—The conditions here are roughly parallel to those encountered in pleural effusion, provided the lung is air bearing and is equidistant from the chest-wall in each case, except that with pneumothorax a marked loss in sound intensity, instead of occurring at the lung-fluid junction, is met with at the air-chest-wall junction. If the lung in the case of pneumothorax is solid, a very serious loss in sound intensity will take place at the lung-air junction. If an open fistula between a bronchus and the pleural cavity exists, the vocal resonance will be increased.

We gratefully acknowledge our indebtedness to those who have furthered this undertaking with their assistance and interest. We wish especially to thank Dr. H. R. M. Landis, Dr. Paul A. Lewis, Dr. G. W. Norris, Dr. Samuel Rhoads, Dr. E. J. G. Beardsley, Dr. C. P. Dorwarth, Dr. T. G. Miller, Dr. W. E. Lee, and Mr. A. G. Margot, and Professor H. C. Richards, of the Department of Physics in the University of Pennsylvania.

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ELEVENTH REPORT

OF THE

HENRY PHIPPS INSTITUTE

FOR THE STUDY, TREATMENT, AND PREVENTION OF TUBERCULOSIS

A STUDY OF THE HOUSING AND SOCIAL CONDITIONS IN SELECTED DISTRICTS OF PHILADELPHIA

BY

FRANK A. CRAIG, M.D.
INSTRUCTOR IN MEDICINE

PUBLISHED BY THE
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PREFACE.

The clinical and pathological aspects of disease have proved such attractive fields for study that physicians have not given the relation between disease and social conditions the attention its importance demands. This indifference has of late years been replaced by an increasing interest in the varied and complex social conditions, with a view to determining what bearing they may have upon disease, this interest being in a large measure due to the wide-spread interest in tuberculosis, a disease peculiarly and intimately connected with every phase of the living and working conditions of the individual.

No study of economic conditions is complete that does not take into consideration disease as a factor, and no study of disease can be considered exhaustive that does not take into account the living conditions and social customs of the people affected. These conditions and customs are of importance not only from their bearing upon the mode of infection, transmission, and causation of disease, but also from their influence upon the progress or course of disease.

The general living conditions are so much affected by race and environment that what might be true of the people of one city, might not apply to those living in another city. This is particularly true of the cities of the United States, with their populations made up of numerous races, and mixtures of races, placed under new and unaccustomed conditions. While certain broad rules might be formulated to cover the conditions in many cities, numerous exceptions are encountered which render them useless in any attempt to apply them in the individual case.

It was believed that a detailed and thorough study of the housing and living conditions of a small area or areas of different nationalities in our own city would give a clearer insight into those conditions influencing the course or causation of disease, and might have some value as a comparison to similar studies in other cities and countries.

We wish to acknowledge our indebtedness to Mr. Bernard J. Newman and Mr. Carol Aronovici for many valuable suggestions in the formulating of our methods of investigation and tabulation of our results.

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A STUDY OF THE HOUSING AND SOCIAL CONDITIONS IN SELECTED DISTRICTS OF PHILADELPHIA.

INTRODUCTION.

GENERAL PLAN AND SCOPE OF INVESTIGATION.—DISTRICTS STUDIED.

The following investigation was undertaken about two years ago, the actual work of investigation covering a period of about one and one-half years. The inspection of the houses and the obtaining of information in regard to the families were performed by the following workers of the Social Service Department of the Henry Phipps Institute, under the direction of Miss Lucinda Nelson Stringer; Miss Elizabeth Whitten, Miss Dorothy M. Ferree, Miss Agnes Jacobs, and Miss Jennie Ferris. The colored worker who made the investigations in the negro districts, Mrs. M. R. Tucker, was provided through the generosity of the Whittier Center.

One of the districts studied was almost entirely inhabited by Russian Jews, one by Italians, and three widely separated districts by negroes. As a means of comparison or control the houses and social conditions of 372 consecutive patients and their families were studied in the same manner. The Jewish district comprised one block, and ran from Second to Third Streets, and from Bainbridge to Catharine. The Italian district, also one block, ran from Eighth to Ninth Streets, and from Carpenter Street to Washington Avenue. The negro districts covered portions of three blocks, namely, from Broad to Thirteenth Streets and from Lombard to South; a second, running from Naudain to Rodman Streets, and from Sixteenth to Seventeenth Streets; the third running from Ninth to Tenth, and Lombard to South Streets. The patients were scattered through the central-eastern and south-eastern portions of the city.

The number of houses investigated was 1003, and the number of people living in these houses 5812.

The districts were selected because they were considered average, typical blocks of the races living in that portion of the city, and not because they were the worst that could be found, which is too frequently a defect in investigations of this kind, giving a distorted and abnormal picture of the average living conditions. The races were selected because they constitute the large proportion of the patients attending the dispensary of the Institute. To have made the picture in any way typical of the city as a whole, other portions of the city should have been included, and this point is to be borne in mind in the consideration of the results, which, while applying only to certain small areas in one section of the city, are fairly typical of one large section. The points upon which accurate and detailed information was desired, and toward the obtaining of which the study was chiefly directed, were—*First, the house:* If any defects were found in the house, to determine which was the most important from the standpoint of the health or safety of the household; which the most frequent; who was responsible for them; with possibly suggestions for their correction. *Second, the living conditions* of the people themselves. We wished to determine their earning capacity; cost of rent; cleanliness; density of population; conveniences or defects in their home life—all the above points to be considered as a whole, and then comparison to be drawn between the various races studied. It must be understood that in studying various districts a few were found who did not belong to the predominant race. Their number was so small that it was felt that in grouping them with the race of that district, it would not affect the general results or conclusions based thereon. The cards used in the field work were copied after those devised by Mr. Bernard J. Newman, Executive Secretary of the Philadelphia Housing Commission, with some minor changes. (See Appendix.)

The districts studied were located in the older section of the city, the houses all having been erected many years ago. This problem of old houses, erected for single families and now occupied by several families, and constituting really the "tenement houses" of this city, is one which is becoming more and more serious in the life of the city, from the standpoint both of health and of safety. It is a problem which should receive the most careful consideration from every one interested in the public welfare. So much attention has been devoted to the construction of houses, building regulations, city planning, model tenements, etc., that the problem of the older houses, with their transformation into tenements, has been somewhat ignored. This is one of the most important questions we have to deal with in this city, as it must be in many other cities in this and other countries. The question of whether these houses are defective, and if so in what regard, becomes extremely important, especially if these defects are slight and easily corrected.

CHARACTER OF NEIGHBORHOOD.

The study would not be complete if it did not make some reference to the neighborhood in which these blocks are located. Through the courtesy of the Philadelphia Board of Recreation we are permitted to publish a map covering the districts studied. (See Appendix.) This shows at a glance the number of churches, playgrounds, public baths, settlement houses, hospitals, etc., situated in the vicinity of these blocks which have just been studied. The words "Jewish," "Italian," and "Colored" on the map correspond very closely with the location of the blocks studied of these races. One of the negro blocks was about half way between the words "Jewish" and "Italian" on the map, and the third negro block was much further south and west than the district shown on the map. It is unfortunate that the map does not also show the location of the saloons.

HOUSING.

GRADING OF HOUSES ACCORDING TO THE SPECIAL CLASSIFICATION.

In an effort to standardize results and to facilitate comparison with the results obtained by similar investigations, the houses have been classified according to the following plan:

100 per cent.	Good ventilation. Good light. Inside toilet and bath.
80 per cent.	Good ventilation. Good light. Outside toilet. Water in house.
60 per cent.	Fair ventilation. Fair light. Outside toilet. Outside water supply.
40 per cent.	Poor ventilation. Poor light. Outside privy. Limited, outside water supply.
20 per cent.	Very poor ventilation. Very poor light. Outside water supply limited. Outside privy (filthy and unsafe). House in bad repair generally.
0 per cent.	Dark rooms. Building unsafe. No possibility of securing sufficient air space.

While this classification possesses some of the defects common to most systems, it presents a fairly accurate picture of the house, especially from the standpoint of light and air. Some of the special features of the housing, such as sewage, plumbing, dampness, construction, etc., will be considered separately. The houses in this report may possibly be graded somewhat high, as we have tried to keep in mind, in estimating the grade of the house, what constituted the essentials for the health and ordinary convenience of the tenants, and did not attempt to base the grading upon what would be considered ideal conditions.

Grouping the houses according to the classification given above gives the following figures:

TABLE 1.—NUMBER AND PERCENTAGE OF HOUSES OF EACH GRADE.

Grade	Total		Jewish		Italian		Negro		Patients	
	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.
100.......	100	9.9	24	7.7	10	7.3	5	2.7	61	16.4
80........	175	17.5	59	19.0	27	19.9	10	5.4	79	21.2
60........	453	45.2	123	39.7	93	67.8	90	48.9	147	39.5
40........	69	6.9	30	9.7	4	2.9	..	..	35	9.4
20........	23	2.3	23	7.4	..	..	..	..	..	..
0.........	183	18.2	51	16.5	3	2.1	79	43.0	50	13.5
Total.....	1003	100.0	310	100.0	137	100.0	184	100.0	372	100.0
Per cent. ..	100.0	..	30.9	..	13.7	..	18.3	..	37.1	..

Table 1 shows the grading of the houses in the different districts, while nearly three-fourths (72.6 per cent.) of all houses examined were graded above 40, the majority (45.2 per cent.) were graded at 60, the grade given to houses possessing certain features considered objectionable but probably to a great degree remediable. It will be noted that 18.2 per cent. of all houses examined were marked "zero," or, in other words, were unfit to live in.

Maps have been prepared of the districts investigated, in which each house is marked in a manner to indicate its housing grade in order to provide a comprehensive view of each district. These maps bring out in a very clear way several features that are worthy of special mention. The most striking of these is the fact that while very good houses ("100"—marked □) are scattered irregularly and fairly evenly throughout the blocks, the very bad houses ("0"—marked ■) are usually in groups, with only a few of them scattered irregularly throughout the districts. This is also true of the bad houses ("20"—marked ▧), the fairly bad houses ("40"—marked ▩) showing a tendency toward this grouping, but not to the same degree as the "0" and "20" houses. This is especially striking on Maps 2, 3, and 4. This is so very marked and constant that it would seem that there must be some explanation for the finding of these defective houses grouped together. While not being able to give the exact cause for this finding, several suggestions are offered which might account for the condition.

The explanation which first suggests itself is that the defective houses might be the common property of one individual, corporation, or estate. Another, that they might possibly have been built at the same time, by the same individual, thus accounting for their common defects. Another possibility is that one house may have been allowed to get into very bad condition, with a consequent lowering of the rents in that house. As a result of this the rents may have been affected in the adjoining properties, with a corresponding decline in the upkeep of these adjoining buildings, the bad housing in the first building being primary, and in the adjoining properties secondary, to the lowering of the rents. It is unfortunate that no information was obtained which would shed any light upon this subject, as it possibly is of considerable importance, especially if the last explanation offered is the true one, which would indicate that bad housing is conducive to bad housing in the adjoining properties. This grouping of the defective houses is noted in all the maps with the exception of one of the negro districts (Map 5), where the investigation was necessarily very incomplete, the houses not investigated (marked in red) being very numerous. The reason so many of these houses were not investigated was because the investigator was a colored social worker and could not gain entrance to the houses marked in red, which were occupied mainly by white people, two of the streets being largely occupied by Jewish storekeepers, and another street being a residence street of very well-to-do people. This occupation of the central portion of blocks of the better residential districts by negroes is a very peculiar and unfortunate arrangement, especially for the negroes. The houses are usually so crowded together and in such bad condition that only the poorest negroes will occupy them. This cannot help but have a bad effect upon the value of the surrounding properties. This state of affairs is not only fairly common in the central portion of the city, but is also becoming more prevalent in certain portions of West Philadelphia as well.

Another very striking feature is that if one studies the buildings upon the rear lots in the different districts, one will note the almost constant low grading of these rear houses. These houses have been built upon the rear lots by the owners, to increase the amount of revenue from the properties (the so-called "greed houses" of some writers), and have proved a very serious menace to the health of the community in this country, as well as in England and Scotland, where in their improvement schemes these buildings have been condemned in large numbers and torn down by the city authorities. While they are not sufficiently numerous at present to warrant such extreme measures as the British have employed, steps should be taken to limit their construction and condemn such as are not amenable to improvement.

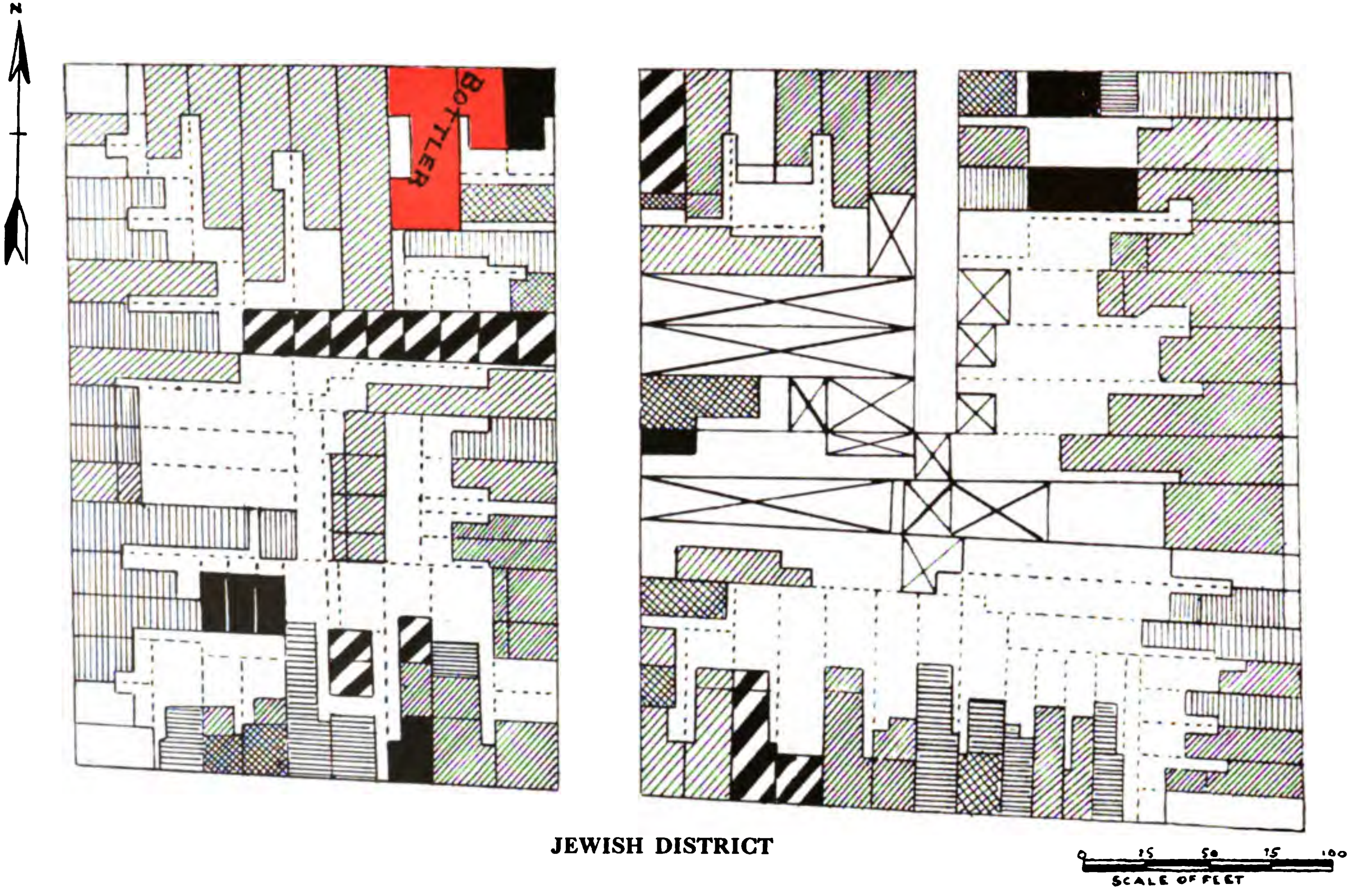
MAPS OF DISTRICTS INVESTIGATED.

EACH HOUSE BEING MARKED TO INDICATE THE GRADE OF HOUSING.

KEY TO THE MARKING OF HOUSES.

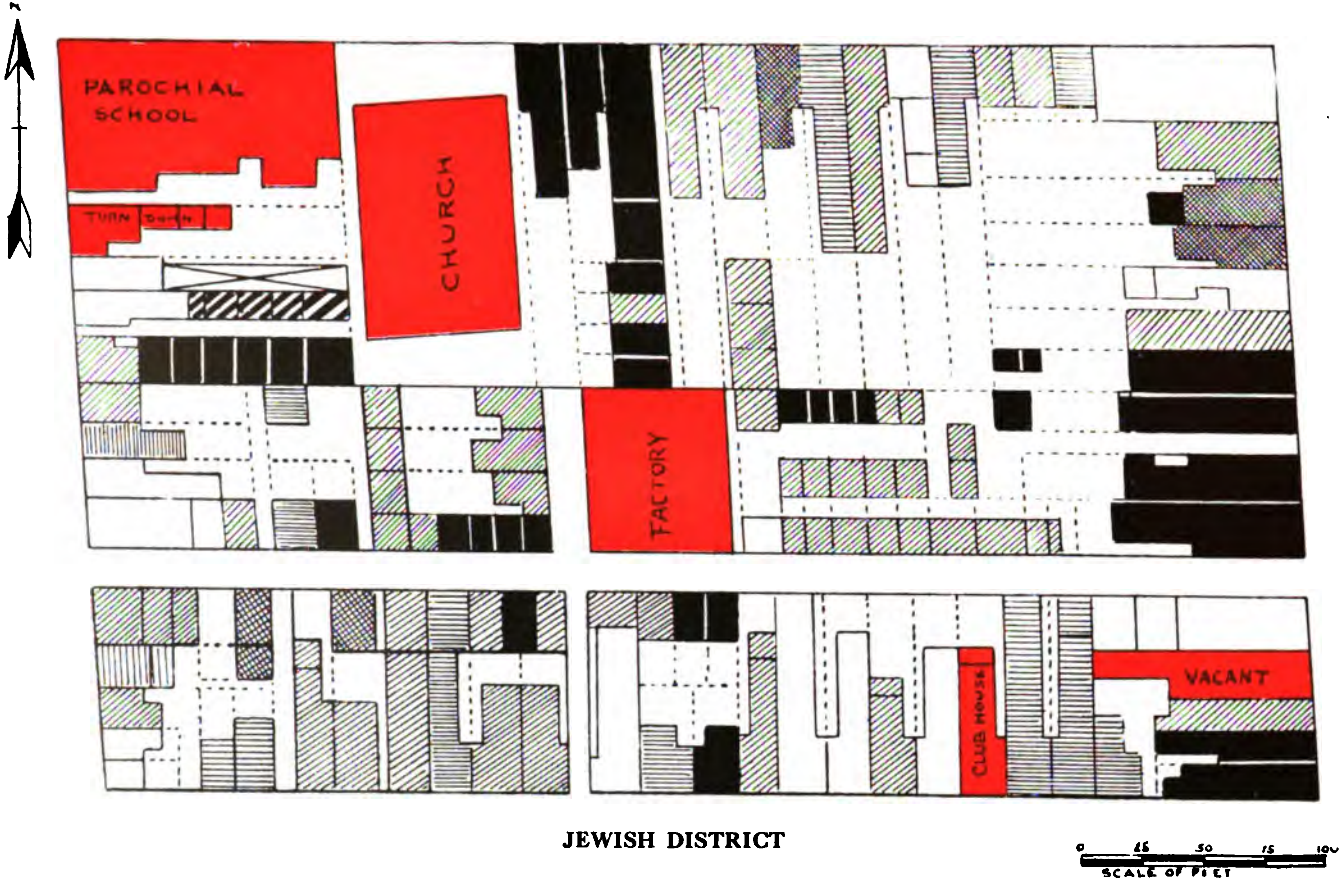
□	"100" VERY GOOD.
▤	"80" GOOD.
▧	"60" FAIR.
▩	"40" FAIRLY BAD.
▧	"20" BAD.
■	"0" VERY BAD.
◘	NOT EXAMINED.

MAP NO. 1



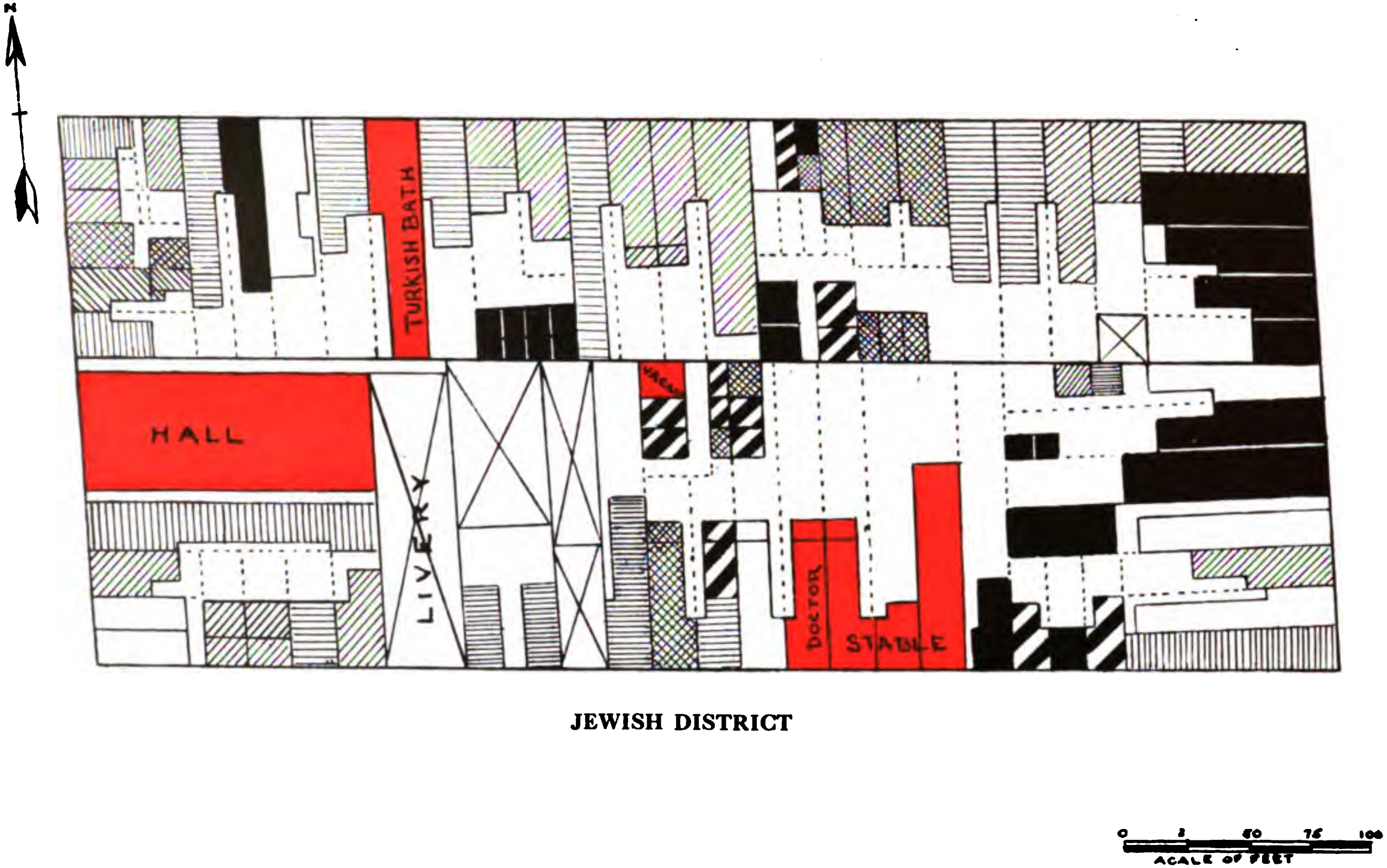
JEWISH DISTRICT

MAP NO. 2



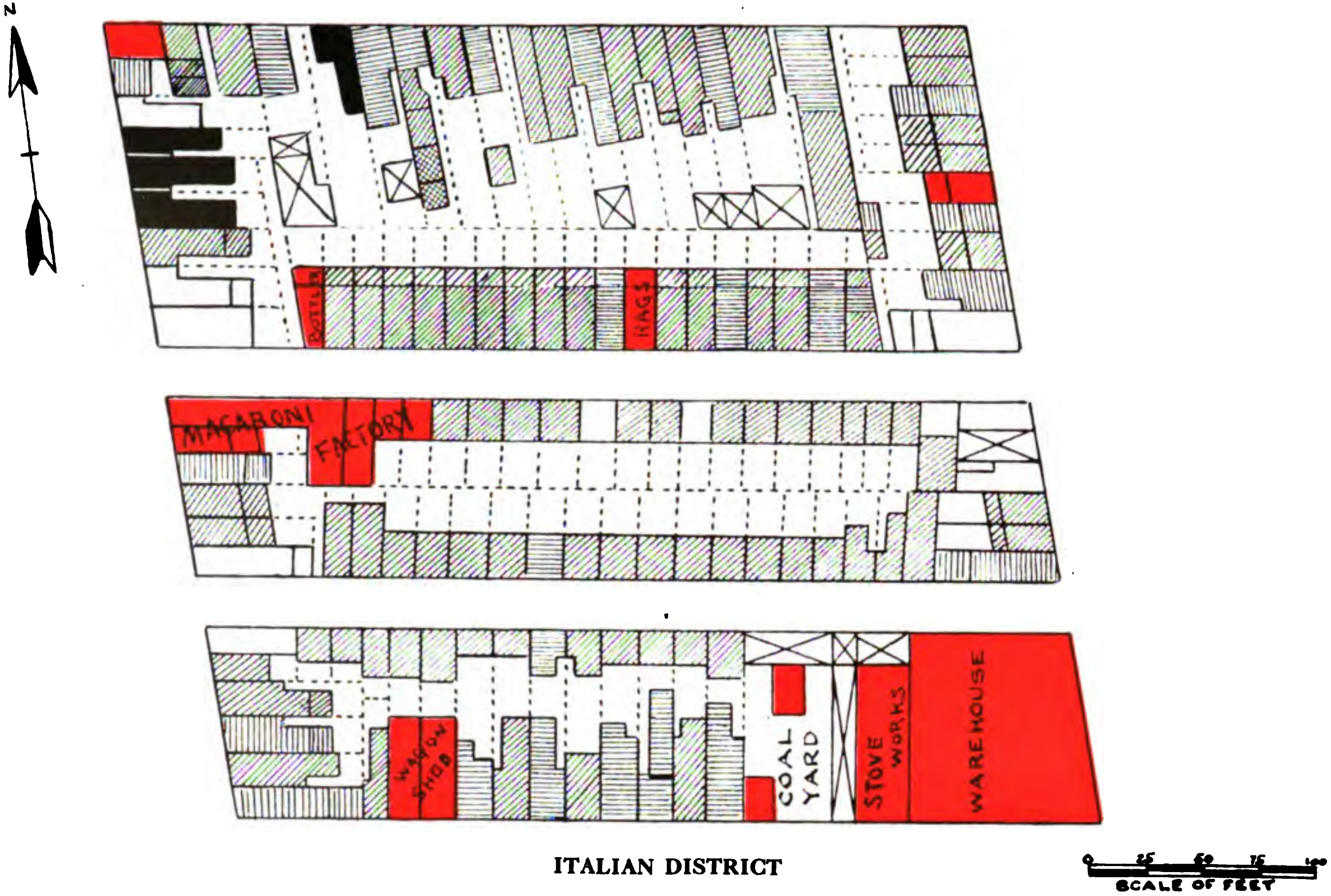
JEWISH DISTRICT

MAP NO. 3



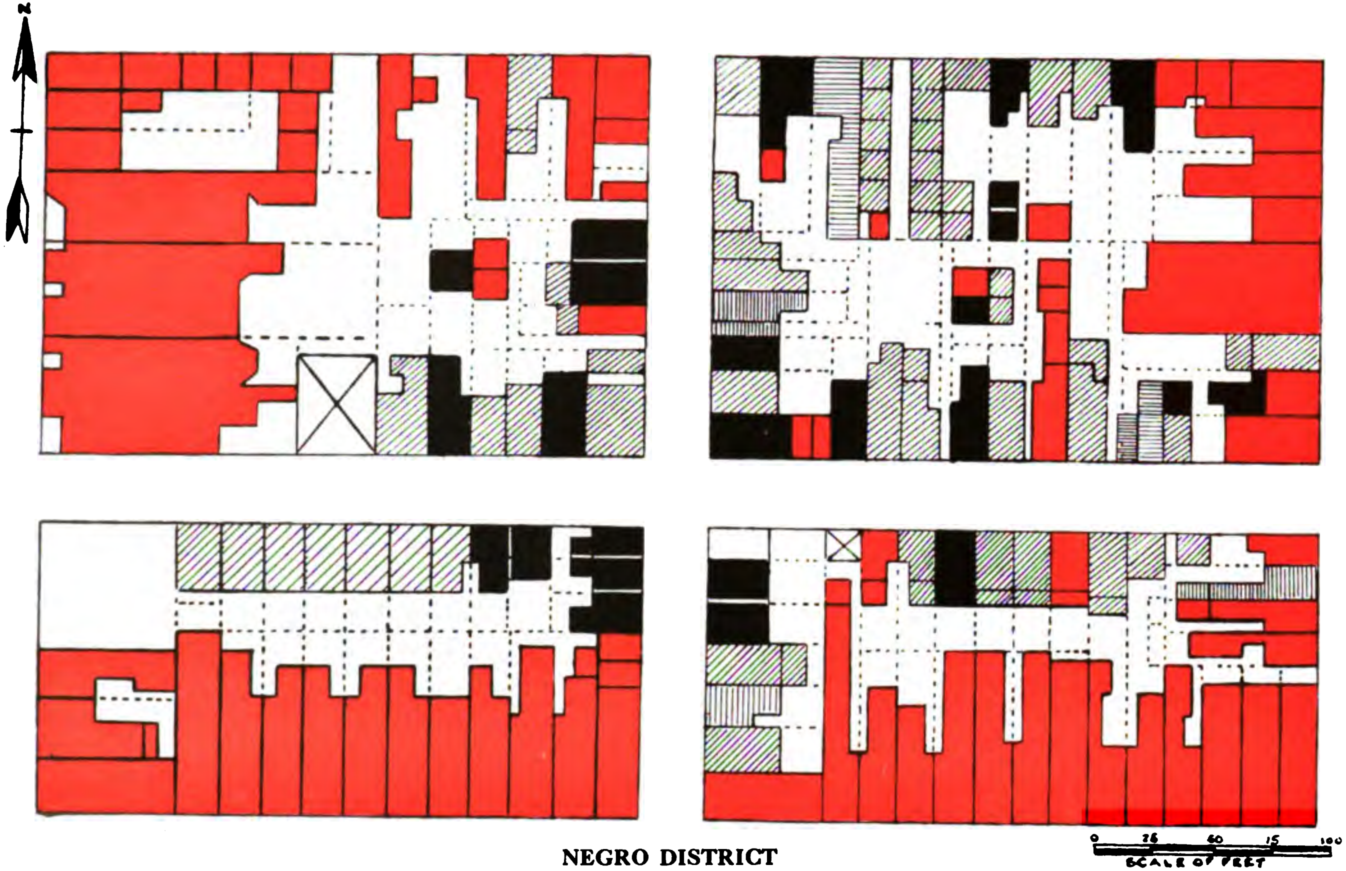
JEWISH DISTRICT

MAP NO. 4



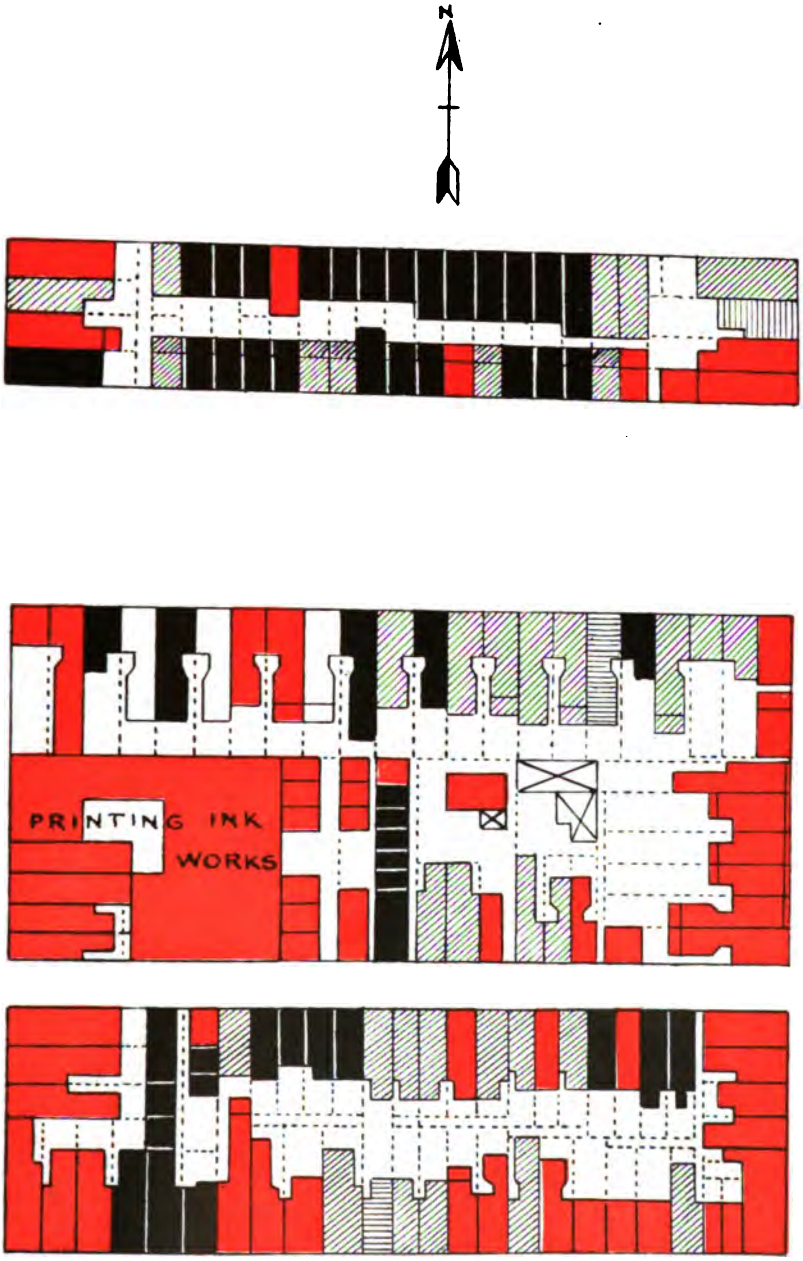
ITALIAN DISTRICT

MAP NO. 5



NEGRO DISTRICT

MAP NO. 6



NEGRO DISTRICT

It will be seen that a moderate number of the houses have been divided into two separate dwellings—a front and a rear. While this arrangement may have certain disadvantages, especially from the standpoint of the persons occupying the rear portion, the amount of privacy which it assures to the two families makes it preferable to the dividing of the house according to floors. This is especially true as the houses are not arranged with stair facilities for several families.

While the study of the housing is extremely important, one only appreciates the importance of the housing conditions when one studies the number of people who are subjected to their varying conditions. The health and welfare of the people occupying the houses are, after all, the only interest one can have in studying the housing. This question is considered in a study of the proportion of the population of the districts studied living under the various grades of houses, thus determining to what extent these people are exposed to the evils of bad, and the benefits of good, housing. As one would expect, the percentages correspond very closely to the percentages found under the study of the houses themselves (Table 1).

Table 2 shows the proportion of population living in houses of the different grades. This is given for all the people studied, and then according to the different races.

TABLE 2.—NUMBER AND PERCENTAGE OF POPULATION LIVING IN HOUSES OF EACH GRADE.

Grade	Total		Jewish		Italian		Negro		Patients' Families	
	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.
100........	544	9.4	207	8.4	85	7.9	18	2.4	234	15.3
80........	1257	21.6	703	28.7	300	27.7	53	7.0	201	13.2
60........	2722	46.8	910	37.0	665	61.5	384	50.9	763	50.1
40........	347	6.0	205	8.4	8	0.7	..	..	136	8.9
20........	152	2.6	152	6.2	..	..	..	..	..	..
0........	790	13.6	276	11.3	24	2.2	299	39.7	191	12.5
Total.....	5812	100.0	2453	100.0	1082	100.0	754	..	1525	100.0
Per cent...	100.0	..	42.2	..	18.6	..	13.0	..	26.2	..

A study of Table 2 brings out several points that are of considerable interest and importance. Of all the people studied, 31 per cent. lived in houses that were graded above "60," and 69 per cent. "60" and under. This means that one-third of the people living in the blocks covered by this investigation were living under fairly good housing conditions, although the majority (46.8 per cent.) were living in houses graded at "60," which is just below the dividing line. Of the remaining fourth, one-half of them (13.6 per cent. of entire number) were living in houses that were condemned by the investigation as absolutely unfit to live in. On the other hand, only 9.4 per cent. of all the people studied were living under very good conditions. One is struck by the relatively small number whose homes can be considered very good, and one hesitates to think what it would mean if this proportion held good for an entire city, instead of only a small section of the same (5812 out of a population of 1,549,008).

The Jewish district, and the houses occupied by the patients, over half of whom were Jewish (58 per cent.), very closely approached this general average. The Italian and negro districts form a very decided contrast, not only to each other, but to the average for the entire district. The Italians showed 35.6 per cent. of their population living in houses above a grade of "60," with only 2.2 per cent. living in houses graded at "0." There is a possibility that by accident the Italian district selected was above the average for that race. An effort was made to avoid this error by consulting a prominent Italian who is thoroughly familiar with this section of the city, and he considered the block selected to be fairly typical of the Italian section.

The negroes, on the other hand, were found to have only 9.4 per cent. of the people living in houses above a grade of "60," and 39.7 per cent. of them living in houses graded at "0." This very striking deviation from the average can have but one explanation that is at all satisfactory, and that is that no houses are open to the negro except the poorest, and after they are once occupied by negroes, no effort is made on the part of the owner to keep the property in repair. After a neighborhood once becomes known as a negro neighborhood, it is extremely rare for a shifting of the population to occur which will restore to it white tenants again. This probably accounts for the deterioration which the houses are allowed to undergo.

The Italians apparently are considered desirable tenants, and are able to secure better homes than even the Jewish. Here the question of rent and income and ownership of homes complicates the problem, which will be considered later. It is interesting to note that the "patients" and their families showed by far the largest percentage occupying houses of 100 grade (15.3 per cent.). As the information upon which this study was based was obtained immediately after the first visit of the patient to the dispensary, the education of the patient by the social workers can hardly be given the credit for this unusually high percentage of good houses. There is a possibility that the patients may have received some instruction in what constitutes good housing by some agency before they applied to the Phipps Dispensary. A study of the cases shows that 45.5 per cent. had never been treated before, 27.5 per cent. had been treated in a sanatorium or hospital, and 27 per cent. had been treated by a private physician. Assuming that, of those treated by a private physician, 10 per cent. had been instructed in what housing conditions they should have (this is a very high estimate), we still find that only about one-third of the cases (30.2 per cent.) had received instruction in what their condition demanded, as far as the home itself is concerned. This is not sufficient to explain the situation. It has been suggested that the tax upon the patient's energy, in the effort to secure sufficient funds to be able to secure the better house, has been so great as to cause the breakdown in their health. Some light might be thrown upon this view if we consider how long after the coming to this country the breakdown occurred. Of the 281 upon whom we had sufficient data to base an opinion as to when the disease occurred, 63 (22.5 per cent.) were native born. Of the 218 foreign born, 10 had developed the disease before entering this country; of the 208 remaining, 65 (31 per cent.) developed the disease within five years of their immigration, 80 (28.5 per cent.) within ten years, 36 (17.5 per cent.) within nineteen years, and 27 (13 per cent.) within twenty years or more. These figures are extremely interesting, and would tend to show that the changed conditions under which they were forced to live and work in this country did have some relation to the development of the disease. It is certainly very suggestive that *69.5 per cent. of the foreign-born patients developed their disease within ten years of their arrival in this country.*

HOUSING IN DETAIL.

While the study of the housing according to the classification employed is extremely interesting, and seems to be fairly accurate, it does not show in a very clear way just what and where are the most common defects in the housing, which it is essential to know if we wish to offer any suggestions for the correction of some of the housing evils. As the grade of the house is decided upon by the investigator, there is considerable opportunity for the personal element to influence the figures upon which the conclusions are based. This is especially true as all houses do not fall definitely and clearly into a certain grade, but occasionally are what might be termed "borderline" houses, where the final grade of the house is left entirely to the judgment of the worker.

The various factors upon which the question of housing is based are considered in detail, with the object of determining the prevalence of some of the more common defects.

SURROUNDINGS AND LOCATION.

A good general idea of the districts studied may be gained by a study of the streets surrounding and traversing the blocks under consideration.

TABLE 3.—WIDTH OF STREETS IN ALL DISTRICTS COMBINED.

WIDTH OF STREETS	NUMBER OF STREETS	LENGTH OF STREETS	PER CENT.
20 to 30 feet.........	6	2,890 feet	25.9
31 to 40 feet.........	2	533 feet	4.8
41 to 50 feet.........	15	6,831 feet	61.2
Over 50 feet.........	2	903 feet	8.1
Total...........	25	11,157 feet	100.0

The majority of the streets were over 40 feet in width (69.3 per cent.) if we consider the length of the streets of each width. This means that nearly 70 per cent. of the running feet of all the streets in the districts studied provided the houses facing them with sufficient air and light. Even the narrower streets have a fairly good width for houses of three stories high. As a rule, the buildings on the narrower streets are only two stories in height. It is only when the buildings are four stories and over that the streets of the widths named are insufficient as far as air and light are concerned. Of course, three-story houses on a 20-feet wide street would render the front rooms on the south side of the street rather gloomy in winter, but even then there would be no reason why they should not have sufficient air.

One of the features not infrequently encountered in Philadelphia is the finding of houses which have been built in the rear of the front or street houses. Sometimes they are built facing each other, thus forming a "court"; in other instances they are erected in a single row of three or more houses with a narrow space in front. In the blocks studied there were in all 118 houses of this type (85 Jewish; 8 Italian; and 25 negro). While it is realized that houses of this type are often objectionable, this is not always the case. Many courts are met with which are extremely desirable from the standpoint of air and sunshine. This question of the courts will be made the subject of a separate study in the future.

The *alleys* also are frequent sources of bad housing conditions. Narrow, dark, usually damp, and without a proper air-supply, they have no redeeming features to recommend them except the saving of space. No matter how carefully they are drained and cleaned, their most important defects admit of no improvement. Their removal by the destruction of adjoining property would prove so costly as to be almost prohibitive. Several cities in Scotland and England have torn down rows of smaller houses in order to provide the adjoining properties with sufficient air and sunshine, with a corresponding decrease in the death-rate in the improved sections.

The Property Alleys.—These narrow passageways between two houses, usually built over by the houses themselves, readily provide dark, damp spaces for the accumulation of filth. They are usually gutters for the surface drainage of the yards and yard hydrants. While not so important from the standpoint of the health of the surrounding individuals as the blind alleys or small through alleys (block alleys), they certainly deserve some consideration. They were found in the different districts in the following numbers:

TABLE 4.—NUMBER OF PROPERTY ALLEYS IN EACH DISTRICT.

Jewish	120, or about one to every	3 houses.
Italian	35, or about one to every	4 houses.
Negro	1, or about one to every	184 houses.
Patients	23, or about one to every	15 houses.
Total	179, or about one to every	5 houses.

The property alley varies in its frequency very much in the different parts of the city, according to the arrangement of the houses. A very important indication, which we may assume from its presence, is that where the property alley is found there are no lots running through from street to street, but the houses face the street and the back yards are joined to the back yards of the houses facing on the rear street. It may, therefore, be taken as frequently indicating insufficient air and sunshine in the rear of the house. Table 4 shows that while only one was found in the negro district, it was very common in the Jewish and Italian districts. This is especially significant in the latter, when we compare it to the good conditions of the houses themselves.

Blind Alleys.—These are very serious defects in any district, and their correction is a very difficult problem. The number found in each district is given in Table 5.

TABLE 5.—NUMBER OF BLIND ALLEYS IN EACH DISTRICT.

Jewish	36, or about one to every 9 houses.
Italian	0
Negro	7, or about one to every 26 houses.
Patients	10, or about one to every 30 houses.
Total	53, or about one to every 18 houses.

In Tables 4 and 5 the alleys are compared to the number of houses, as this was the only means possible of showing their relative frequency in the different districts.

Although the property alleys were so frequent in the Italian district, we find no blind alleys. The blind alleys were most frequent in the Jewish districts, as were also the property alleys. From the standpoint of arrangement of houses, therefore, the Jewish district was the worst encountered.

TABLE 6.—NUMBER AND PERCENTAGE OF ALLEYS OF DIFFERENT WIDTHS.

Width	Total		Jewish		Italian		Negro		Patients	
	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.
Less than 3 feet	39	24.7	23	21.1	7	25.0	0	0	9	56.3
3 to 6 feet	98	62.0	71	65.1	17	60.7	4	80.0	6	37.5
Over 6 feet	21	13.3	15	13.8	4	14.3	1	20.0	1	6.2
Total	158	100.0	109	100.0	28	100.0	5	100.0	16	100.0

Table 6 does not include property alleys, but does include a few through and through or block alleys. This accounts for the larger number of alleys considered. It will be noticed that one-fourth of all the alleys are less than three feet in width, which is a very high proportion of exceedingly narrow alleys. We have selected these figures rather arbitrarily, but an alley that is less than three feet in width is certainly too narrow for any neighborhood as built up as those under consideration. Narrow alleys are objectionable not only on account of their obstruction to traffic, but when one considers that these are frequently the only place upon which the people can place their garbage and refuse for collection, that the sun rarely enters them, and that there is no free access for air, their effect upon the health of those living in the neighborhood may be readily imagined. Even alleys six feet in width can hardly be considered as desirable in a district where the houses are frequently built side by side, and where most of the lot is covered.

TABLE 7.—NUMBER AND PERCENTAGE OF HOUSES FACING STREET, ALLEY, AND BACK YARD.

Facing on	Total		Jewish		Italian		Negro		Patients	
	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.
Street	742	82.7	209	70.6	115	87.1	137	78.3	281	95.6
Alley	133	14.8	79	26.7	10	7.6	34	19.4	10	3.4
Back yard	22	2.5	8	2.7	7	5.3	4	2.3	3	1.0
Total	897	100.0	296	100.0	132	100.0	175	100.0	294	100.0

The table showing the number of houses facing the street, alley, or back yard gives one a much better idea of the district stated than does the number of alleys alone. The number of alleys without any statement as to their length, or number of houses facing on them, may be very misleading. When one learns, however, that of all the houses examined, about one-sixth (17.3 per cent.) faced an alley or a back yard, the actual conditions in the districts are more clearly understood. The custom of adding small buildings on the rear of others or dividing houses into two dwellings accounts for the number found facing the backyard (2.5 per cent.), which was found more frequently than one would expect, and constitutes a very bad housing feature.

It will be noted that, although the negro district has very few blind and property alleys, the number of houses facing on alleys is very high (19.4 per cent.), being only second to the Jewish district, which showed 26.7 per cent. facing alleys. It will be seen, however (Table 6), that the negro district did not have any very narrow (less than three feet) alleys, most of them being between three and six feet in width. The Italian district has the highest percentage of houses facing the back yard (5.3 per cent.), which is, as a rule, as bad as facing an alley, dependent entirely upon how nearly the lots are covered by buildings.

As the houses occupied by patients were scattered over a large section of the city, it is hardly just to make any comparison between conditions found there and the districts studied house by house. It is, however, interesting to note that they showed the highest percentage of houses facing on the street. This is a very curious fact, and one that is very difficult to explain. One would think at first that, perhaps, they might have been advised to live in houses where the supply of air and the amount of sunlight were greater. The same remarks that were made under housing (p. 13) hold good here, and require no further reference. This problem cannot be solved without further information in regard to several points. One is so accustomed to think of tuberculosis as being very prevalent in the alleys and small streets, that one feels there must be some explanation for this very unexpected finding.

PROPORTION OF LOT COVERED BY BUILDING.

There is nothing which quite as completely and accurately pictures the degree to which a district is "built up" as by giving the percentage of lot covered by the building. There is also no more important point from the standpoint of the health of the tenants of that district.

That this point is considered important one may judge from the fact that the housing laws of many large cities place a limit to the size of tenement building upon any plot of ground, giving specifically the proportion which must remain free of obstruction. Both New York and Boston allow only 65 per cent. of the lot to be covered by the building. The Philadelphia law in regard to the tenement houses ("Every building . . . occupied as a residence by three or more families living independently of each other and doing their cooking upon the premises") is that they shall cover only 80 per cent. of the lot, this open space to be unobstructed, with exceptions made for corner houses and houses with streets on three sides, where streets are not less than 20 feet in width.

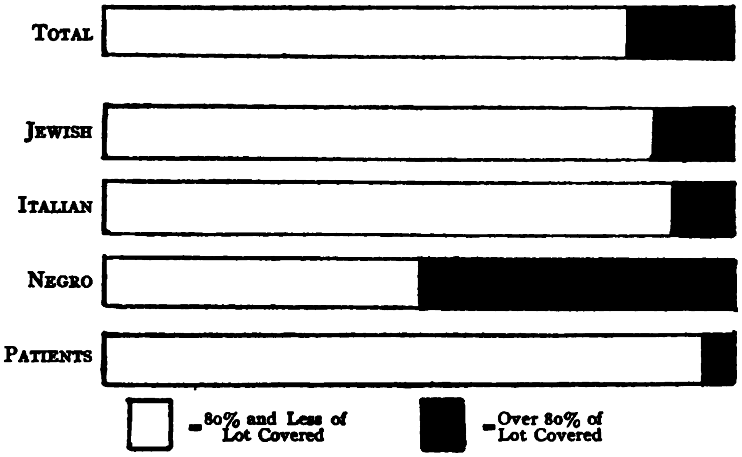
Upon the proportion of the lot covered by building depends the amount of air and sunlight obtained by those living in that vicinity, and to a certain degree the limiting of the size of the building to be placed on any plot of ground serves to control the number of people living in that district. Unfortunately, the last-mentioned object of the statute is rendered inoperative by overcrowding and increasing the height of the building.

TABLE 8.—PROPORTION OF LOT COVERED BY BUILDING.

Per Cent. of Lot Covered	Total			Jewish			Italian			Negro			Patients		
	Number	Per Cent.	Over and Under 80 Per Cent.	Number	Per Cent.	Over and Under 80 Per Cent.	Number	Per Cent.	Over and Under 80 Per Cent.	Number	Per Cent.	Over and Under 80 Per Cent.	Number	Per Cent.	Over and Under 80 Per Cent.
33 or less	85	11.3	84.4	19	8.7	88.5	5	4.0	91.3	0	0	50.7	61	22.7	95.5
34 to 66	318	42.3		47	21.7		71	56.3		70	50.0		130	48.3	
67 to 80	232	30.8		126	58.1		39	31.0		1	0.7		66	24.5	
81 to 90	99	13.2	15.6	9	4.1	11.5	9	7.1	8.7	69	49.3	49.3	12	4.5	4.5
100	18	2.4		16	7.4		2	1.6		0	0		0	0	
	752	100.0	..	217	100.0	..	126	100.0	..	140	100.0	..	269	100.0	..

GRAPHIC CHART OF TABLE 8.

PROPORTION OF LOT COVERED BY BUILDING.



According to the figures of Table 8 it will be seen that of all the houses examined, 15.6 per cent. covered a greater proportion of the lot than the law allows for tenement houses. The law allows corner houses on streets 20 feet wide or over to be entirely covered, and so an effort was made to eliminate such buildings from the table. The data upon this point among the patients were not sufficient to determine which were corner houses, and so they were not considered.

TABLE 9.—PROPORTION OF LOT COVERED BY BUILDING, OMITTING CORNER LOTS.

Per Cent. of Lot Covered	Total			Jewish			Italian			Negro			Patients[1]		
	Number	Per Cent.	Over and Under 80 Per Cent.	Number	Per Cent.	Over and Under 80 Per Cent.	Number	Per Cent.	Over and Under 80 Per Cent.	Number	Per Cent.	Over and Under 80 Per Cent.	Number	Per Cent.	Over and Under 80 Per Cent.
33 or less.....	24	5.2	78.8	19	9.0	89.5	5	4.2	91.6	0	0	50.4	..	..	..
34 to 66......	184	39.8		47	22.4		71	59.7		66	49.6		..	..	..
67 to 80......	156	33.8		122	58.1		33	27.7		1	0.8		..	..	..
81 to 90......	82	17.7	21.2	8	3.8	10.5	8	6.7	8.4	66	49.6	49.6	..	..	..
100..........	16	3.5		14	6.7		2	1.7		0	0		..	..	..
	462	100.0	..	210	100.0	..	119	100.0	..	133	100.0	..	..	..	..

[1] No data available to determine which were corner houses among the patients.

Taking into consideration those houses about which sufficient information was obtained to determine whether they were houses which would fall under the building laws, and eliminating all corner houses, it was found that 21.2 per cent. of them had more of the lot covered than the law allows for tenement houses.

As the law considers all houses occupied by three families tenement houses, the attempt was made to determine how many houses were occupied by three or more families, not corner houses, and at the same time had the lot covered to a greater extent than allowed by law (80 per cent.).

In the negro districts there were 11 houses, each occupied by from three to eight families, in which the houses covered 90 per cent. of the lot.

In the Jewish districts there were five houses, each occupied by from three to nine families, three of which covered 90 and two 100 per cent. of the lot.

In the Italian districts there were four houses, each occupied by from three to eight families, one of which covered about 90 and three 100 per cent. of the lot.

Thus, there were found to be 20 houses in direct violation of the law in all the districts examined (omitting patients from the estimation). The estimation of the proportion of lot covered by the building was expressed in percentage without giving the area of lot or building, but may be accepted as being approximately correct.

An occasional lot entirely covered by the building might not be very objectionable, provided that the buildings in the neighborhood covered but a small portion of the lot, as it would not interfere greatly with the sunlight and would allow a free circulation of air. It is a very important question to determine to what extent each block is covered with buildings, as one would, therefore, be in a better position to judge the degree to which the blocks were built up. This is a very difficult problem to determine accurately, but a study of the maps (p. 10) of the various districts will give one a fairly good idea of the proportion of the various blocks covered by the buildings. It will be noted that all the blocks are about equally covered, with the exception of the Italian district, where most of the houses have fairly large back yards. A study of the maps of the negro districts would seem to indicate that the estimation of the percentage of lot covered was possibly somewhat high.

NUISANCES.

One is constantly impressed with the difficulty in accurately estimating the extent to which the various housing and living conditions affect the health of the community, and in no instance is this so great as in the study of the various nuisances common to large cities. The loud noises, foul gases, smoke, and odors emanating from the burning of coal, from factories, privies, domestic animals, etc., are so indefinite, and their effect upon the health of the neighbors so little understood, that it seemed best to indicate their occurrence without further comment, although our own opinion in regard to them is that they are a great deal more harmful than usually appreciated. It has been suggested that unpleasant odors tend to diminish inspiration and also encourage the closing of windows. It must be remembered also that many odors may be not only objectionable in themselves, but that they are frequently an indication of the presence of various conditions which are distinctly injurious to the health of the surrounding community. Thus the odors arising from inclosures for domestic animals and privies may indicate the presence of excreta exposed to the air, with the possibility of contamination of the air by the excreta in the form of dust, or by its being carried into the dwellings through the medium of the house-fly.

TABLE 10.—DOMESTIC ANIMALS.

Animals	Times Encountered
Cats	182
Dogs	107
Fowls	41
Horses	6

The actual number of animals was not recorded, the numbers simply indicating the number of times they were encountered. As one would expect, the dogs were encountered relatively more frequently among the negroes. One is so accustomed to believing that fowls are frequently kept by the Jews that it was a great surprise to find them more frequent among the Italians. Thirteen stables were found, 10 of which were occupied. Rats were found infesting the buildings on several occasions, and vermin were encountered only once.

Other *nuisances* are given below, the number of times they were encountered, and their source:

TABLE 11.—NUISANCES AND THEIR SOURCES.

Nuisances	Times Encountered	Sources of Nuisances	Times Encountered
		Privies	140
		Water-closets	33
Odors	227	Houses, yards, and cellars	16
		Animals	14
Noises	15	Railroad	8
		Factories	6
		Coal yard	2
Smoke and dust	13	Garbage	2
		Chimney	1
		Fish store	1

The smoke coming from the railroad was complained of eight times, and was probably not mentioned more frequently because the people in the neighborhood had become accustomed to its presence. The railroad runs along one of the streets bordering the Italian district, and is for the use of freight trains, with their frequent stops and shifting, with the result that the smoke is much more annoying than would be the case if the tracks were used for high-speed trains. The same objections referred to on preceding page under "odor" apply equally here, with the exception of the last.

The one feature which stands out in the list of nuisances is the frequent complaint of odors from privies. This will be dealt with in detail in the section on privies and toilets.

YARDS.

Many of the conditions found in the yards are of such a nature that their significance is self-evident and requires no special mention. In the following tables are shown the results of the investigation, with only occasional notes to explain or emphasize special points.

TABLE 12.—RUBBISH IN YARD.

	TOTAL		JEWISH		ITALIAN		NEGRO		PATIENTS	
	Times	Per Cent.	Times	Per Cent.	Times	Per Cent.	Times	Per Cent.	Times	Per Cent.
Free	410	44.5	99	45.8	54	42.8	113	41.7	144	46.8
Some	394	42.8	72	33.3	64	50.8	152	56.1	106	34.4
Much	117	12.7	45	20.9	8	6.4	6	2.2	58	18.8
Total	921	100.0	216	100.0	126	100.0	271	100.0	308	100.0

In Table 12 it will be noted that while the Jews and patients showed a slightly higher percentage of yards entirely free of rubbish, the Italians and negroes, especially the latter, showed a much smaller percentage of yards containing a great deal of rubbish. While rubbish in itself cannot be considered a very serious menace to the health of the people in the neighborhood, it may readily serve as a place for the harboring of disease-producing bacteria, where they may be so protected that their life, or disease-producing capacity, would be prolonged.

The presence of rubbish may also be taken as an index of the low hygienic standard of the people dwelling in the house. As both of these indications are of considerable importance, the presence or absence of rubbish has sufficient significance to warrant its being reported.

CLEANLINESS.

TABLE 13.—CLEANLINESS OF YARDS.

	TOTAL		JEWISH		ITALIAN		NEGRO		PATIENTS	
	Times	Per Cent.	Times	Per Cent.	Times	Per Cent.	Times	Per Cent.	Times	Per Cent.
Clean	581	69.7	157	58.8	103	80.5	154	88.0	167	63.3
Dirty	205	24.6	85	31.8	22	17.2	18	10.3	80	30.3
Filthy	48	5.7	25	9.4	3	2.3	3	1.7	17	6.4
Total	834	100.0	267	100.0	128	100.0	175	100.0	264	100.0

Information was obtained in regard to the cleanliness of the yards in 834 instances—69.7 per cent. of them found clean, 24.6 per cent. were dirty, and 5.7 per cent. were so bad as to deserve the designation filthy. The worst conditions were found among the Jews and patients, who showed a much smaller proportion of cleanly yards than either the Italians or negroes. The maintenance of a clean yard is sufficiently difficult when it is used by only one family, but when ten or more families share the responsibility, as very often happens, cleanliness becomes increasingly difficult.

One of the worst features of the city back yard is the high board fence which surrounds these small enclosures. The object of the high fence is to secure privacy, and while this may be desirable, it undoubtedly encourages carelessness. The modern tendency is to do away with these high fences, partly to secure more open space, and partly to make inspection of the yards easy. In one of the recent reports of the Philadelphia Board of Health the recommendation is made that the erection of these high fences be prohibited by law. A yard which is readily open to inspection tends to check the careless householder from throwing the rubbish accumulated in the house out of the back door; furthermore, an inspector can examine a large number of back yards without having to enter each inclosure.

DRAINAGE.

TABLE 14.—CLEANLINESS OF DRAIN.

	NUMBER	PER CENT.
Clean	682	89.4
Dirty	64	8.4
Filthy	17	2.2
Total	763	100.0
	TIMES	PER CENT.
Free	625	92.5
Obstructed	51	7.5
Total	676	100.0

The yard drainage was found to be connected with the sewer 711 times (76.9 per cent.), to be merely surface drainage in 213 (23.1 per cent.) instances, and was inadequate 150 times (23.1 per cent.).

TABLE 15.—DAMPNESS.

	NUMBER	PER CENT.
Dry	326	53.0
Damp	228	37.0
Water	61	10.0
Total	615	100.0

When one considers that 10 per cent. of the yards had water lying in them, 23 per cent. had surface drainage, and 21 per cent. had insufficient drainage, one cannot help but feel this must have some effect upon the health of the people in the neighborhood.

WATER SUPPLY.

TABLE 16.—CONDITION OF HYDRANTS.

	NUMBER	PER CENT.
Good	742	85.7
Fair	68	7.8
Bad	56	6.5
	866	100.0

TABLE 17.—WATER SUPPLY.

	NUMBER	PER CENT.
Adequate	740	90.5
Deficient	70	8.6
None	8	0.9
	818	100.0

The cleanliness of the yards might not depend solely upon the people, but might be affected to a certain extent by the water supply in the yard, although it is extremely doubtful to what extent the hydrants are used for flushing the yards, being chiefly used for household purposes. When the water supply of this part of the properties was studied, it was found that 85.7 per cent. of the yard hydrants were in good condition, and in 90.5 per cent. of them the supply was adequate.

NUMBER OF FAMILIES USING SINGLE HYDRANTS.

While less than half of the hydrants were used by a single family, nearly one-fourth of them were used by three or more families. In one instance 11 families had but the one hydrant between them, the average for the entire group being two families to a hydrant. In many instances this was the only water supply the house possessed.

TABLE 18.—NUMBER OF FAMILIES USING SINGLE HYDRANTS.

FAMILIES PER HYDRANT	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	TOTAL	
Times occurring .	232	178	50	20	14	10	5	2	13	0	1	525	Average: 2.1 families per hydrant
Number of families	232	356	150	80	70	60	35	16	117	0	11	1127	
Percentage	44	34	22									100	

RECEPTACLES FOR GARBAGE AND ASHES.

The information in regard to this question was not as complete as one would desire, due to the fact that the ashes and garbage are placed outside for removal on certain days only, and were thus frequently missed by the inspectors of the houses. The question is an extremely important one, not only because they should be placed in receptacles which would properly retain them while they are awaiting removal, especially the garbage in the summer time, but also to facilitate their removal by the proper authorities without having them scattered in the yards and streets.

It was noted that the receptacles were unsuitable in 122 instances and were inadequate in 90 instances. This was so marked in 15 of the cases as to constitute a nuisance in the opinion of the investigator.

The garbage was kept in tin cans in about two-thirds of the cases (51 out of 77) recorded, and boxes, pails, and barrels in the remainder.

The ashes were kept in boxes almost entirely.

YARD TOILETS.

There are several points in regard to the yard toilets that are very important from the standpoint of the health of the people using them or living in their neighborhood: (1) They should be of the proper construction, have sewer connection, and some system for their flushing with water. (2) They should be kept in repair. (3) They should be accessible. (4) They should be sufficient in number to accommodate the people.

The laws of the city regulate the construction of the toilets, going into considerable detail in regard to sewer connection, flushing, ventilation, etc. That this law is effective mainly in the construction of new houses is due to the lack of provision for the proper inspection of the older dwellings. The law definitely states that no cesspool or privy vault should be continued on any plot of ground where there is a sewer adjoining. Nor shall any cesspool or privy vault be connected with the sewer. There were found 252 privy vaults in the districts examined in direct violation of this law; of these, 38 had no sewer connection at all and 47 had no provisions for flushing with water. It is not uncommon also to find, even where there is some provision for flushing, that the water is shut off during the winter months. Unfortunately, no figures were obtained in regard to this point. There can be no question as to the injurious effect of these privy vaults upon the health of the community, it being sufficiently apparent to any one who gives the matter the least study. These privy vaults are being removed every year in large numbers, and probably as fast as the number of inspectors provided can accomplish, but it is certainly a matter of such grave importance to the health of the community that it is to be regretted the authorities cannot or will not provide sufficient trained inspectors to handle this matter thoroughly and efficiently. The mere presence of these privies is bad enough, but when one finds only 16 per cent. of them in good repair and over half of them (57 per cent.) in very bad repair, they constitute a very grave menace to the health of the people.

TABLE 19.—STATE OF REPAIR OF YARD TOILETS.

	Privies		Water-closets	
	Number	Per Cent.	Number	Per Cent.
Good	41	16.0	437	72.0
Fair	68	27.0	116	19.0
Bad	143	57.0	55	9.0
Total	252	100.0	608	100.0

TABLE 20.—CLEANLINESS OF YARD TOILETS.

	Privies		Water-closets	
	Number	Per Cent.	Number	Per Cent.
Clean	148	59.0	497	77.0
Dirty	60	24.0	105	16.0
Filthy	44	17.0	44	7.0
Total	252	100.0	646	100.0

The yard water-closets are in striking contrast to the privies in regard to their state of repair, as 72 per cent. of the former were in good repair and only 9 per cent. in very bad repair. This may possibly be accounted for by the fact that they were of more recent construction, and had not had sufficient time to deteriorate, or by the fact that, owing to their construction, with water connections, etc., it is necessary to keep them in proper repair to have them operable. They are also probably better constructed and less likely to get out of repair. The people using them also probably take more interest in keeping them in good repair. This may be judged by the fact that the cleanliness of the water-closets was much better than the privies—the difference between 77 and 59 per cent. While 17 per cent. of the privies were filthy, only 7 per cent. of the water-closets were found in this condition. It is certainly unfortunate that yard toilets are permitted in the city unless it is impossible to place them within the house, as they are most inconvenient and liable to get out of repair, especially during very cold weather, and are not kept as clean as they would be if they were within doors. It would be practically impossible to do away with those existing at present, but some provision might be made in regard to preventing any more being built. The removal of the privies would help matters very materially, as the condition of the water-closets was comparatively good.

TABLE 21.—NUMBER OF COMPARTMENTS IN YARD PRIVIES.

Compartments per Privy	I	II	III	IV	V	VI	Total	
Times occurring	121	94	17	11	5	4	252	Average: 1.8 compartments per privy.
Number of compartments...	121	188	51	44	25	24	453	
Percentage ..	48.0	37.0	7.0	8.0			100.0	

TABLE 22.—NUMBER OF FAMILIES USING EACH YARD PRIVY.

Families per Privy	I	II	III	IV	V	VI	VII	VIII	Total	
Times occurring	161	52	15	13	6	1	3	1	252	Average: 1.7 families per privy.
Number of families........	161	104	45	52	30	6	21	8	427	
Percentage ..	64.0	21.0	6.0	9.0					100.0	

TABLE 23.—NUMBER OF COMPARTMENTS IN YARD WATER-CLOSETS.

Compartments Per Closet	I	II	III	IV	V	VI	Total	
Times occurring	590	26	12	2	0	1	631	Average: 1.1 compartments per closet.
Number of compartments...	590	52	36	8	0	6	692	
Percentage ..	93.5	4.1	1.9	0.5			100.0	

TABLE 24.—NUMBER OF FAMILIES USING EACH YARD WATER-CLOSET.

Families Per Closet	I	II	III	IV	V	VI	VII	VIII	X	Total	
Times occurring	377	114	41	13	11	7	7	2	1	573	Average: 1.6 families per closet.
Number of families........	377	228	123	52	55	42	49	16	10	952	
Percentage ..	65.8	20.0	7.1	7.1						100.0	

A very important point for consideration is the number of families using the toilets, for where a single toilet is used by many families it is impossible to keep it as clean as it should be kept and in the proper repair, thus increasing the possibility of transmission of disease either directly or through the medium of the house-fly. The lack of sufficient toilet facilities is well recognized as a contributing factor in the immorality of the people, so that its importance is not only from the standpoint of health.

The present study showed that over one-third of the families using the yard privies and yard water-closets (36 and 34 per cent., respectively) shared them in common with other families.

TABLE 25.—AVERAGE FAMILIES PER YARD COMPARTMENT.

	Yard Privies	Yard Water-closets	Total
Total number of compartments....	453	692	1145
Total number of families..........	427	952	1379
Average number of families per 100 compartments................	94	137	120

TABLE 26.—NUMBER OF COMPARTMENTS IN YARD PRIVIES AND WATER-CLOSETS.

COMPARTMENTS PER TOILET	I	II	III	IV	V	VI	TOTAL	
Times occurring	711	120	29	13	5	5	883	Average: 1.29 compartments per toilet.
Number of compartments	711	240	87	52	25	30	1145	
Percentage	80.5	13.6	3.3	2.6			100.0	

TABLE 27.—NUMBER OF FAMILIES USING EACH YARD PRIVY AND WATER-CLOSET.

FAMILIES PER TOILET	I	II	III	IV	V	VI	VII	VIII	X	TOTAL	
Times occurring	538	166	56	26	17	8	10	3	1	825	Average: 1.67 families per toilet.
Number of families	538	332	168	104	85	48	70	24	10	1379	
Percentage	65.2	20.1	6.8	7.9						100.0	

If the yard privies and water-closets are combined (Tables 25, 26, and 27), it is found that there were in all 1145 compartments which were used by 1379 families, or 120 families to every 100 compartments. Leaving out of consideration the 538 families having a toilet of their own, one finds that among one-third of the families using yard toilets there were 607 compartments used by 841 families, or 138 families to every 100 compartments. In other words, there were 345 privies and water-closets used by 841 families, or among one-third of those using yard toilets there were 244 families to every 100 privies and water-closets, with an average of 1.3 compartments per closet or privy. The number of compartments varied very much, the privies having only 48 per cent. with one compartment, while the water-closets had 93.5 per cent. Of the privies and water-closets having more than one compartment, the average was 2.5 compartments per privy, and the same for the water-closets.

CONSTRUCTION OF BUILDINGS.

It will be seen that nearly all the houses (97.9 per cent.) were constructed of bricks. This is a very good building material, and one which requires very little attention to keep in good repair for many years. The buildings under investigation were constructed for the most part many years ago, when the construction of the buildings was more thorough and enduring. The fact that they have lasted so many years is in itself proof of this statement. This city is not confronted with the problem of the frame buildings to the same degree as many of the American cities, where a large proportion of the buildings of the same class as those under consideration are built almost entirely of wood. The 17 buildings entirely or in part of frame construction are a very serious fire menace in a city as densely built up as this portion of Philadelphia. That the frame buildings suffer quickly from lack of repair is also a very great disadvantage to that type of construction. They are also very difficult to heat, which the tenants attempt to overcome by closing up every opening to the outer air, which seriously interferes with the proper ventilation.

TABLE 28.—CONSTRUCTION MATERIAL.

Material	Times	Per Cent.
Brick	834	97.9
Frame	15	1.8
Brick and frame	2	0.2
Stone	1	0.1
Total	852	100.0

TABLE 29.—NUMBER OF STORIES.

Number of Stories	Times	Per Cent.
One and one-half	1	15.5
Two	109	
Two and one-half	9	
Three	588	76.7
Three and one-half	1	7.8
Four	59	
Total	767	100.0

The sections of the city studied have also the advantage of not having many tall buildings to interfere with the light and ventilation, to say nothing of the many serious objections to the concentration of population in a limited area.

It will be noted that only 7.8 per cent. of the buildings, 60 in all, were over three stories in height, and there were none over four stories.

The many reasons why these smaller houses are found so frequently in Philadelphia has been very thoroughly dealt with by Miss Parrish, in her article entitled "One Million People in Small Houses."

REPAIR.

TABLE 30.—STATE OF GENERAL REPAIR.

	NUMBER	PER CENT.
Good	372	43.0
Fair	102	12.0
Bad	390	45.0
Total	864	100.0

The study of Table 30 gives one a very good idea of the age of most of the buildings in the districts studied, as the lack of repair can be considered as being in direct proportion to their age. One would naturally expect the buildings of this class to show a certain number in bad repair, but it certainly does not speak very well for the owners when more houses were found in bad repair than in good, 45 and 43 per cent. respectively, although they were still inhabitable. There seems to be a fine opportunity for a thorough study of the situation in the entire city in regard to this question, with the object of establishing some supervision, with possibly the necessary legislation, which will place the responsibility for this lack of repair where it belongs and enforce its correction. These older buildings do not receive the attention from the health authorities their prevalence demands when one considers the effect of this lack of repair upon the health and safety of the tenants. Here the danger of increasing the rents complicates the problem, which interferes with so many of the plans for improving the housing conditions of this class of people.

FIRE-ESCAPES.

During the investigation 34 fire-escapes were encountered. These were distributed through the Jewish and Italian districts, and in the houses occupied by the patients, none being found in the negro districts. In districts as densely populated as the ones studied safety in case of fire is an extremely important one, and a subject which must be considered in any article dealing with the health and welfare of the community. The protection against fire is as important as against disease, and seems to be equally difficult to secure. Here again is found the defect, common to so many health and safety measures, of having sufficient legislation, but a very imperfect machinery for enforcing the existing laws.

PLUMBING.

The returns made by the investigators in regard to the various piping systems in the houses were imperfect. To study these systems in such a way that the information obtained will be at all satisfactory requires the services of inspectors specially trained in this sort of work, and possessing information which is possessed by but few people. For this reason no comment is made upon the various findings under this heading, but simply a tabulation of the figures obtained.

TABLE 31.—HOUSE DRAIN.

	Number	Per Cent.		Number	Per Cent.		Number	Per Cent.
Exposed...	224	55.0	Free......	202	94.0	Sound	145	89.0
Covered ...	185	45.0	Obstructed	13	6.0	Patched...	18	11.0
Total....	409	100.0	Total....	215	100.0	Total....	163	100.0

Material: Iron............ 443 Test cap................ 83

OPENINGS.

None	1
One	4
Two	3
Three	2
Six	1
Total	11

CELLARS.

There can be no question as to the importance of the cellar in the general hygiene of the house, and its effect upon the health of the people living in the house. While this view is almost too prevalent among the laity, who consider a good cellar as the one essential feature of a healthy home, and blame a bad one for most of the illnesses occurring in the house, it must be conceded that a damp, dark, poorly ventilated cellar must have some effect upon the general health of those who have to live in the dwelling portion above it. This is particularly true when the cellar-basement is used for living quarters.

TABLE 32.—PURPOSE FOR WHICH CELLAR-BASEMENT IS USED.

	Number	Per Cent.
Ordinary	745	79.1
Business	84	9.0
Storage	79	8.0
Living	31	3.0
Kitchen	5	0.5
Sleeping	4	0.4
Total	948	100.0

Excluding those cellar-basements used for ordinary purposes or storage (79.1 and 8 per cent.) from the above table (Table 32), one finds that 124, or 12.9 per cent., of those examined were used for such purposes as living, sleeping, business, and cooking. Under these conditions the ventilation, cleanliness, and dampness of the cellar are as important as in any portion of the dwelling proper.

TABLE 33.—DAMPNESS.

	Number	Per Cent.		
Dry	538	67.5	In all weather	115
Damp	211	26.5	Only in rain and storm	11
Water	48	6.0	Due to leak	1
Total	797	100.0	Total	127

TABLE 34.—FLOORING MATERIAL.

	Number	Per Cent.
Earth	648	64.7
Cement	173	17.3
Wood	155	15.5
Brick	25	2.5
Total	1001	100.0

TABLE 35.—DAMPNESS: ACCORDING TO DISTRICTS.

	Total		Jewish		Italian		Negro		Patients	
	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.
Dry	538	67.5	151	68.0	95	74.0	87	53.0	205	73.0
Damp	211	26.5	62	28.0	26	20.0	60	36.0	63	22.0
Water	48	6.0	10	4.0	7	6.0	18	11.0	13	5.0
	797	100.0	223	100.0	128	100.0	165	100.0	281	100.0

In the districts investigated there was found an unusually high proportion of damp cellars (32.5 per cent.), approximately one in every three houses, 6 per cent. of the entire number having water in them. Among those in which information could be obtained in regard to this point it was found that in the majority (115) this dampness was present regardless of the weather, 11 of them being in this condition only during rain or storm. The question arises as to whether this is due to some fault in construction or to some peculiarity of the subsoil. Some light is thrown upon this point by a study of Table 34, which shows that nearly two-thirds of the cellars have earthen floors, only 19.8 per cent. having a surfacing of cement or bricks. With the large number of earthen and wooden floors, as both of these flooring materials offer very little protection against dampness, it is really surprising that more of them were not damp. The large number of damp and wet yards must also be considered as a factor in the causation of the damp cellar. The worst conditions, as far as dampness is concerned, were found among the negroes (see Table 35), where only slightly more than one-half of the cellars were dry (53 per cent.). The Jewish were next, with 68 per cent. dry, and the best were found among the Italians and patients (74 and 73 per cent. respectively). The negroes also had the highest proportion of cellars with free water in them (11 per cent.). The Jewish presented the smallest percentage (4 per cent.), and the Italians had just a few more than the patients (6 and 5 per cent. respectively). In but one instance was it recorded that the dampness of the cellar was due to leakage from some pipe (Table 33).

TABLE 36.—VENTILATION.

	Number	Per Cent.
Sufficient	597	73.0
Insufficient	221	27.0
Total	818	100.0

TABLE 37.—LIGHT.

	Number	Per Cent.
Light	158	26.0
Gloomy	390	63.0
Dark	68	11.0
Total	616	100.0

That over one-fourth of the cellars (27 per cent.) had insufficient ventilation and over one-tenth (11 per cent.) were very dark is of importance when one considers the number of them used for living purposes. As fresh air and sunlight are two of our greatest natural protective agents against bacterial life, this large proportion of cellars from which they are excluded must have some effect upon the health of the tenants.

TABLE 38.—CLEANLINESS.

	Number	Per Cent.
Clean	506	61.0
Dirty	276	34.0
Filthy	39	5.0
Total	821	100.0

TABLE 39.—STATE OF REPAIR.

	NUMBER	PER CENT.
Good	353	43.5
Fair	403	49.5
Bad	57	7.0
Total	813	100.0

The contrast between cleanliness and repair is again found in studying the cellar, as it has been found in studying nearly every other portion of the dwelling. While one finds 61 per cent. of the cellars clean, there were only 43.5 per cent. in good repair, and with only 5 per cent. of them filthy there were 7 per cent. in very bad repair.

HALLS AND STAIRS.

Any one familiar with the spiral stairs so frequently found in houses of the grade under investigation must have been impressed with the danger of attempting to go up or down them rapidly, especially as so many of them are quite dark. The only influence they might have upon the people living in the house would more properly not come under the heading of health, but of safety. This disadvantage would be of considerable importance in case of fire. That 489 were steep, 509 spiral, and 372 without railing, gives a very clear picture of this portion of the dwelling.

TABLE 40.—STAIRS.

	NUMBER	PER CENT.
Straight	426	45.5
Spiral	509	54.5
Total	935	100.0
Steep		489
Railing present		372

TABLE 41.—NUMBER OF LANDINGS.

One	389
Two	66
Three	39
Four	4
Total	498

TABLE 42.—CLEANLINESS.

	NUMBER	PER CENT.
Clean	681	78.0
Dirty	151	18.0
Filthy	37	4.0
Total	869	100.0

TABLE 43.—STATE OF REPAIR.

	Number	Per Cent.
Good	529	66.0
Fair	260	32.0
Bad	18	2.0
Total	807	100.0

That 78 per cent. of the halls and stairways were found to be clean and only 66 per cent. in good repair conforms with what was found in other portions of the house. Here one meets with 4 per cent. of them filthy, as compared with only 2 per cent. in bad repair. That these portions of the house are in constant use and shared by many families in common might possibly explain this rather high percentage of filthy halls and stairs.

TABLE 44.—HALL SINKS PER HOUSE.

Sinks per House	I	II	III	IV	V	VI	VII	VIII	XII	Total	
Times occurring.	88	21	17	3	6	2	3	1	1	142	Average: 1.9 sinks per house.
Number of sinks	88	42	51	12	30	12	21	8	12	276	
Percentage	62.0	15.0	12.0	11.0						100.0	

Fixtures in Halls.—All hall fixtures are open to the same objection, namely, the lack of individual responsibility for the cleanliness and care of the fixtures. It is difficult, however, where many families are living in one house, to provide separate sinks and toilets for each apartment on account of the expense involved. This question of expense of installation probably explains why hall sinks were found in only 142 of the 1003 houses examined, or about one in every seven houses. When present, we find they averaged nearly two sinks to each house (1.9 per house). It must be recognized that the hall sink is in many instances a very great convenience to the people in the house, and is to be preferred to the yard water-hydrant upon which so many families had to depend for their entire water supply.

Toilets.

TABLE 45.—HALL TOILETS PER HOUSE.

Toilets per House	I	II	III	IV	V	VIII	XII	Total	
Times occurring.	51	27	21	2	6	1	1	109	Average: 1.8 toilets per house.
Number of toilets	51	54	63	8	30	8	12	196	
Percentage	47.0	25.0	19.0	9.0				100.0	

TABLE 46.—NUMBER OF FAMILIES USING EACH TOILET.

Families per Toilet	I	II	III	IV	V	VI	VII	VIII	XII	Total	
Times occurring.	14	39	17	8	8	20	2	1	1	110	Average: 3.3 families to each hall toilet.
Number of families..........	14	78	51	32	40	120	14	8	12	369	
Percentage...	13.0	35.0	15.0	37.0						100.0	

Before considering the above tables it would, perhaps, be best to first quote the laws in Philadelphia covering this subject:

"In every such tenement house there shall be one water-closet for every tenement or suite of rooms which has its own independent hallway, so separated that its rooms do not open into or connect with any other rooms; and in tenement houses so constructed that a tenement may consist of a single room, or of two rooms, there shall be at least one water-closet for every three rooms: Provided: That in the case of buildings existing at the date of this act, which shall hereafter be altered into tenement houses, there shall be one water-closet for six rooms, but not less than one for each floor. Every water-closet shall be separated from every other water-closet and shall have an entrance entirely independent of the entrance to every other water-closet. There shall also be an independent water supply, and at least one sink for every tenement or suite of rooms. No hydrant shall be permitted in the yard or open space provided for in second section of this act."—7 June, 1895, 6, P. L. 180.

It is extremely difficult in a study of this kind to determine which houses fall under the legal definition of a tenement house (see section under Percentage of Lot Covered by Building). It was found impossible to compare the findings with the legal requirements, as the data collected were not always sufficiently complete to classify our apartments according to the legal definition. Fortunately, it does not require a knowledge of the law to imagine the condition resulting from the facts that there were 57 instances where the hallway toilets were used by more than two families, and excluding the 14 toilets used by one family, the finding of 96 toilets used by 355 families, averaging nearly 3.7 families to each toilet. That there were only 109 houses with hallway toilets is in itself a very significant fact.

ROOFS.

TABLE 47.—TIGHTNESS OF ROOF.

	NUMBER	PER CENT.
Water-tight	806	96.0
Leaking	36	4.0
Total	842	100.0

The general dampness of a house may be influenced to a large extent by the degree to which the roof is impervious to rain. Only 4 per cent. of the roofs were found to leak, which is about what one would expect to find. Those features of the house which add to the comfort of inhabitants or the protection of their household goods are much more likely to receive the attention of the owners of the houses or landlords than those features affecting the health of the people alone. This fact probably accounts for the very low percentage of leaking roofs.

TABLE 48.—RUBBISH ON ROOF.

	NUMBER	PER CENT.
Free	326	83.5
Some	54	14.0
Much	10	2.5
Total	390	100.0

Many of the people living in the crowded districts use the roof as a depository for the rubbish which accumulates in the house, and, therefore, the condition of the roof bears the same relation to the house as rubbish in the yard. It will be noted that while 83.5 per cent. were free of rubbish, 14 per cent. had some, and 2.5 per cent. had much. The 10 instances of *much* rubbish, and 32 out of the 54 instances of *some* rubbish, on the roof were found among the Italians, although it is not at all clear why this race should use the roof for depositing rubbish any more than any other.

APARTMENTS.

The most important point in regard to the apartments is cleanliness, and here it attains a significance which it possesses in no other part of the building, as it is dependent entirely upon one family. There are some factors which may influence it, such as water supply, wife working (either at home or outside the home), wife ill, numerous small children, etc., but its presence or absence gives a very true picture of the family. Further reference is made to this subject under Living Conditions.

A study of Table 49 shows that over half (52 per cent.) of the apartments were clean, and only a little over one-tenth (11 per cent.) were filthy. A comparison of the various districts shows that the negroes present the very best figures in respect to cleanliness of the apartments, having the largest proportion of clean apartments and by far the lowest percentage of filthy ones. The patients, on the contrary, show the lowest proportion of clean apartments and the highest dirty.

TABLE 49.—CLEANLINESS OF APARTMENTS.

	Total		Jewish		Italian		Negro		Patients	
	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.
Clean..........	698	52.0	259	49.0	144	55.0	170	66.6	125	42.0
Dirty..........	498	37.0	205	38.0	88	33.0	80	31.4	125	42.0
Filthy..........	155	11.0	71	13.0	32	12.0	5	2.0	47	16.0
Total.......	1351	100.0	535	100.0	264	100.0	255	100.0	297	100.0

In comparing the various districts in regard to any special feature, such as cleanliness, which is a question of the opinion of the investigator, it must be borne in mind that all the districts were inspected by the same set of workers except the negro districts. The data in regard to these districts were obtained by a colored social worker, who was employed because it was found that she could gain entrance to the homes and obtain information where a white worker would have considerable difficulty. Whether under these circumstances it is quite fair to compare the conditions in one district to those found in another may be open to some question. It was felt, however, that the difference was so striking that it must represent the actual relation between the districts studied. That the apartments of the negroes show a high degree of cleanliness has been repeatedly observed by the other workers of the Institute, although no figures were recorded by them dealing with this point.

TABLE 50.—LIGHTING OF APARTMENTS.

	Total		Jewish		Italian		Negro		Patients	
	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.
Light..........	1199	88.6	454	85.0	232	92.0	258	94.0	255	86.2
Gloomy........	144	10.6	69	13.0	19	8.0	16	6.0	40	13.5
Dark..........	11	0.8	10	2.0	0	0	0	0	1	0.3
Total.......	1354	100.0	533	100.0	251	100.0	274	100.0	296	100.0

The question of light does not appear to be a very great problem in the districts studied, 88.6 per cent. of them being found light, while only one apartment among the patients and 10 among the Jews were found to be dark. The negroes had the best apartments from this standpoint, with 94 per cent. of the apartments being light, the Italians having almost as good with 92 per cent. light. In neither of these districts were any dark rooms found. It is very surprising that there is not a closer relation between the proportion of the lot covered by building and lighting, yet there does not seem to be any relation at all, the negroes having by far the worst conditions in regard to the proportion of lot covered by building and the best lighting. No solution to the problem suggests itself.

TABLE 51.—VENTILATION OF APARTMENTS.

	Total		Jewish		Italian		Negro		Patients	
	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.
Good	952	73.0	343	64.0	217	85.0	175	81.0	217	73.0
Fair	272	21.0	152	28.0	30	12.0	36	16.0	54	18.0
Bad	84	6.0	43	8.0	9	3.0	6	3.0	26	9.0
Total	1308	100.0	538	100.0	256	100.0	217	100.0	297	100.0

One would naturally expect ventilation to follow fairly closely the question of light, although the former is under the control of the people living in the apartments to a much greater extent than the latter. It was found that there was a much higher percentage of bad ventilation (6 per cent.) and a lower percentage of good ventilation (73 per cent.), in comparison with the percentages under lighting (0.8 and 88.6 per cent.).

In the various districts studied, as far as ventilation was concerned, the Italians gave the best figures (85 per cent. good and 3 per cent. bad), with the negroes a close second (81 per cent. good and 3 per cent. bad). The Jewish gave the lowest percentage of good ventilation (64 per cent.) and the patients the highest proportion of bad ventilation (9 per cent.). This has some bearing upon a question raised under Grades of Houses, House Facing, and Proportion of Lot Covered by Building. It was noted that the patients had the greatest proportion of good houses, more houses facing the street, and the largest proportion of houses with only a small percentage of the lot covered, and yet these were the houses from each of which a case of tuberculosis came to the dispensary. It is just possible that the poor showing of the patients in regard to ventilation may have some significance, indicating that the question of ventilation is apparently of more importance than any of the other factors considered. While this is not in any way conclusive, it is at least very suggestive.

WATER SUPPLY.

TABLE 52.—REPAIR OF WATER FIXTURES.

	TOTAL		JEWISH		ITALIAN		NEGRO		PATIENTS	
	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.
Good	693	53.0	298	52.0	154	76.2	78	31.0	163	55.5
Fair	573	43.0	241	42.0	47	23.3	163	65.0	122	41.5
Bad	54	4.0	35	6.0	1	0.5	10	4.0	8	3.0
Total	1320	100.0	574	100.0	202	100.0	251	100.0	293	100.0

The water fixtures in the various apartments were in only a fair condition, but 53 per cent. being in good repair. The negroes had the lowest proportion of water fixtures in good repair (31 per cent.), and the Jews the highest percentage in bad repair (6 per cent.).

TABLE 53.—LOCATION OF WATER SUPPLY.

	TOTAL		JEWISH		ITALIAN		NEGRO		PATIENTS	
	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.
House	565	41.0	267	52.0	77	30.0	96	28.0	125	43.0
Yard	830	59.0	242	48.0	177	70.0	245	72.0	166	57.0
Total	1395	100.0	509	100.0	254	100.0	341	100.0	291	100.0

Less than one-half of the apartments (41 per cent.) had a water supply in the house, the majority (59 per cent.) having to depend upon a supply in the yard. The different districts varied greatly in this respect. Among the negroes, 72 per cent. had a yard supply, and the Italians were nearly as bad with 70 per cent. The Jewish had the best supply of water, with 52 per cent. having it in the house, and the patients were also fairly well supplied, with 43 per cent. in the house.

It is rather astonishing to find that in all the apartments studied only about two-fifths of them were provided with an indoor water supply. When we consider the very severe cold spells occasionally met with in this climate during the winter months, with the attendant danger of freezing of outdoor water-pipes and all the inconveniences accompanying it, it seems almost unbelievable that about two-fifths (41 per cent.) of the population in certain districts are constantly exposed to the risk of having nothing but an outside water supply during the two to three cold months of the year. With such a large proportion of the families dependent upon a water supply in the yard, which in many instances means carrying water for every purpose up two or three flights of stairs, the percentages of cleanliness take on an entirely different meaning, and one which reflects great credit upon the tenants. It is a very curious fact that, while the negroes had the smallest percentage with an indoor supply of water, they had the highest percentage of clean and the lowest percentage of very dirty apartments.

TABLE 54.—SEPARATE WATER SUPPLY.

	Total		Jewish		Italian		Negro		Patients	
	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.
Separate	875	64.5	418	82.0	108	42.0	121	40.0	228	78.0
In common	482	35.5	91	18.0	149	58.0	178	60.0	64	22.0
Total	1357	100.0	509	100.0	257	100.0	299	100.0	292	100.0

Among all the apartments studied, a little less than two-thirds (64.5 per cent.) had a water supply of their own, the remainder sharing the water supply with other apartments.

Summary.—It is exceedingly difficult, in an investigation of this kind, which attempts to cover the entire housing and living conditions, to collect information upon any one special feature, scattered under various headings, and summarize it so that its significance is clear and definite. These features should be made the subject of special investigations.

A special section is devoted to this subject because upon the water supply largely depends the question of cleanliness, which is so extremely important from the standpoint of health.

All the water fixtures noted were located as follows:

TABLE 54 A.—WATER FIXTURES AND THEIR LOCATION.

Yard hydrants	846	(59.9 per cent.)
Hall sinks	276	(19.6 per cent.)
Apartment fixtures	289	(20.5 per cent.)
	1411	
Total families	1354,	or 1.04 fixtures per family.

From the above table one would be led to believe that the families were well supplied with fixtures, but that the location of the majority (59.9 per cent. in yards) was bad. This is, however, very misleading.

Referring to the table under Apartments (Table 53), one finds that over half (59 per cent.) of the families had to depend upon a yard water supply, and that 35.5 per cent. of the families shared fixtures with other families. It is apparent, therefore, that, while the average number of fixtures per family is good, this is due to the fact that two-thirds (64.5 per cent.) of the families have a very good supply of water so far as the number of fixtures is concerned. The large number of yard hydrants, which frequently means carrying all water used in the apartment up two flights of stairs, is apparently a more serious defect than the number of fixtures. The water supply must be regarded as very irregularly distributed (see Table 18, showing number of families using single yard hydrants), and the number of house fixtures entirely inadequate.

TOILETS.

TABLE 55.—LOCATION OF TOILETS.

	TOTAL		JEWISH		ITALIAN		NEGRO		PATIENTS	
	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.
House	222	23.0	115	49.6	27	10.0	19	9.0	61	22.0
Yard	750	77.0	117	50.4	234	90.0	182	91.0	217	78.0
Total	972	100.0	232	100.0	261	100.0	201	100.0	277	100.0

It seems almost incredible that less than one-fourth of the apartments studied had indoor toilet facilities. The worst conditions were found among the negroes, where 91 per cent. of the families had to depend upon outdoor privies and water-closets, the Italians being almost as bad, with 90 per cent. having the same lack of accommodations.

TABLE 56.—SEPARATE TOILETS.

	TOTAL		JEWISH		ITALIAN		NEGRO		PATIENTS	
	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.
Separate	588	43.5	243	50.0	86	30.0	91	46.0	168	60.0
In common	760	56.5	244	50.0	196	70.0	104	54.0	116	40.0
Total	1348	100.0	487	100.0	282	100.0	195	100.0	284	100.0

Less than half (43.5 per cent.) of the apartments had separate toilet facilities, although this is extremely important not only from the standpoint of cleanliness and health, but also from the standpoint of morality—a point upon which numerous investigators have laid great stress. This question of toilets is dealt with later under a special section.

Summary.—Attention has already been called to this feature of the housing under Yard Toilets, but its extreme importance warrants a special consideration of the conditions existing in the entire house.

TABLE 57.—TOTAL TOILETS, COMPARTMENTS, AND FAMILIES USING.

LOCATION	NUMBERS			PERCENTAGES		
	Toilets	Compartments	Families Using	Toilets	Compartments	Families Using
Yard	883	1145	1379	79.9	83.9	74.2
Privies	252	453	427	22.8	33.2	23.0
Water-closets	631	692	952	57.1	50.7	51.2
Hall	110	110	369	10.0	8.0	19.8
Apartments	112	112	112	10.1	8.1	6.0
Total	1105	1367	1860	100.0	100.0	100.0

The above table practically speaks for itself in regard to the number of yard toilets and the proportion of these which are privies existing in opposition of the law. That nearly one-quarter of the families in the districts examined have to depend upon toilets which are so objectionable as to be forbidden by law reveals a state of affairs that is deplorable. That nearly three-fourths of them have to depend upon yard toilets, with all their inconveniences and disadvantages, especially in the winter time, is in itself very unfortunate, to state the matter mildly.

It is only when the existence of such conditions as these is discovered in the homes of these people that one views some of their customs and habits with more lenience. What right have the owners of these houses to offer for rent or sale properties in which such conditions exist?

It is difficult to see why the laws provided for the health and welfare of the entire community, for such conditions do not only affect their immediate environment, are not so arranged as to reach these conditions, and not only affect the new buildings. This policy of only protecting against the erection of new buildings is terribly short-sighted, when it is the older buildings which are the ones which chiefly stand in need of this supervision.

In addition to the fact that both the character of the toilets and the location are bad, one must also consider the supply, whether they are sufficient in number for the accommodation of the people. It was found that there were 1105 toilets to 1354 families, which would mean about 1.22 families per toilet, or 0.99 family to each compartment, approximately one compartment to every family. Therefore, as far as the number goes, it would appear as if there were sufficient, and yet what was said in regard to the water supply holds good here, that some families would have more than sufficient, while others would not have any. That at times many families used one toilet may be seen by a study of Table 22, under Yard Toilets.

As far as we are able to judge from the material collected in these small areas, this question of the toilets is by far the most common defect, and the most important from the standpoint of health.

BATH-TUBS.

The lack of personal cleanliness among the class of people under consideration has been a constant source of surprise and wonderment to every one coming in contact with them. Personal cleanliness is frequently lacking in many who, so far as their clothing and home are concerned, are faultless. The cause for this is not hard to find. Among the thirteen hundred and odd apartments there were found only *247 bath-tubs.* This means about one tub to every 5.4 families, or one in every 3.8 houses. In addition to this, in the winter months the water must be heated in a boiler on the stove in order to make the bathing possible, and in some houses, in addition to this, the water must be carried up two flights of stairs. Try and imagine this same state of affairs in your own home! What would happen to your own standard of "personal cleanliness"?

Most of the Jewish people have to depend upon the Russian baths, for which they pay so much per bath. When the family is large, this means quite an item of expense, with the result that the baths are taken at very infrequent intervals. There can be no question of what the effect of this infrequent bathing must be upon the health of these people. It would seem that, with the public baths provided by the city, some arrangement might be made so that they would be open to the people in the winter, the same as in the summer months. It certainly seems a great waste to allow these properties to stand idle for so many months, especially as the city has to pay for a caretaker during this period.

SUMMARY OF HOUSING.

The various items considered under Housing have been summarized, the results of which are shown in the chart on opposite page. If one examines the combined housing, one notes that the proportion of bad houses is almost identical with the bad houses obtained under the method of grading houses, as seen in Table 1 (page 9). Dividing the houses in thirds, combining "100" with "80," "60" with "40," and "20" with "0," one finds that the houses of "20" and "0" grades combined equal 20.5 per cent. when based on the system adopted. According to the grouping of the various sections of the house part by part, and then combining them, as shown in the chart, the bad houses form 19.4 per cent. This would suggest that the classification adopted for grading the houses is practicable and reliable. The "good" and "fair" houses do not correspond with the results obtained under the special classification because many portions of the houses were merely considered good or bad, bad including all those that were not distinctly good.

The central circle marked "Housing" is merely a summary of the conditions indicated by the circles referring to the different portions of the house and must not be taken as in any way indicating the proportion of good houses found in the investigation (see Table 1, page 9).

The chart shows very clearly where the majority of the defects are to be found. The roof, halls, and apartments were quite good, and the yards, houses, and plumbing were fairly good. The cellars were bad, the water supply was very bad, but the worst condition encountered was the toilet arrangements.

In taking up the various portions of the house and considering them in detail, one finds that the roof was, as a rule, impervious to rain, the halls were in fairly good repair, only a very few being found in very bad repair. The lighting of the apartments was good; the ventilation, while not so good, was very fair.

Studying the building itself, one notes that the construction material was very good, but the houses were in a very bad state of repair. The pro-

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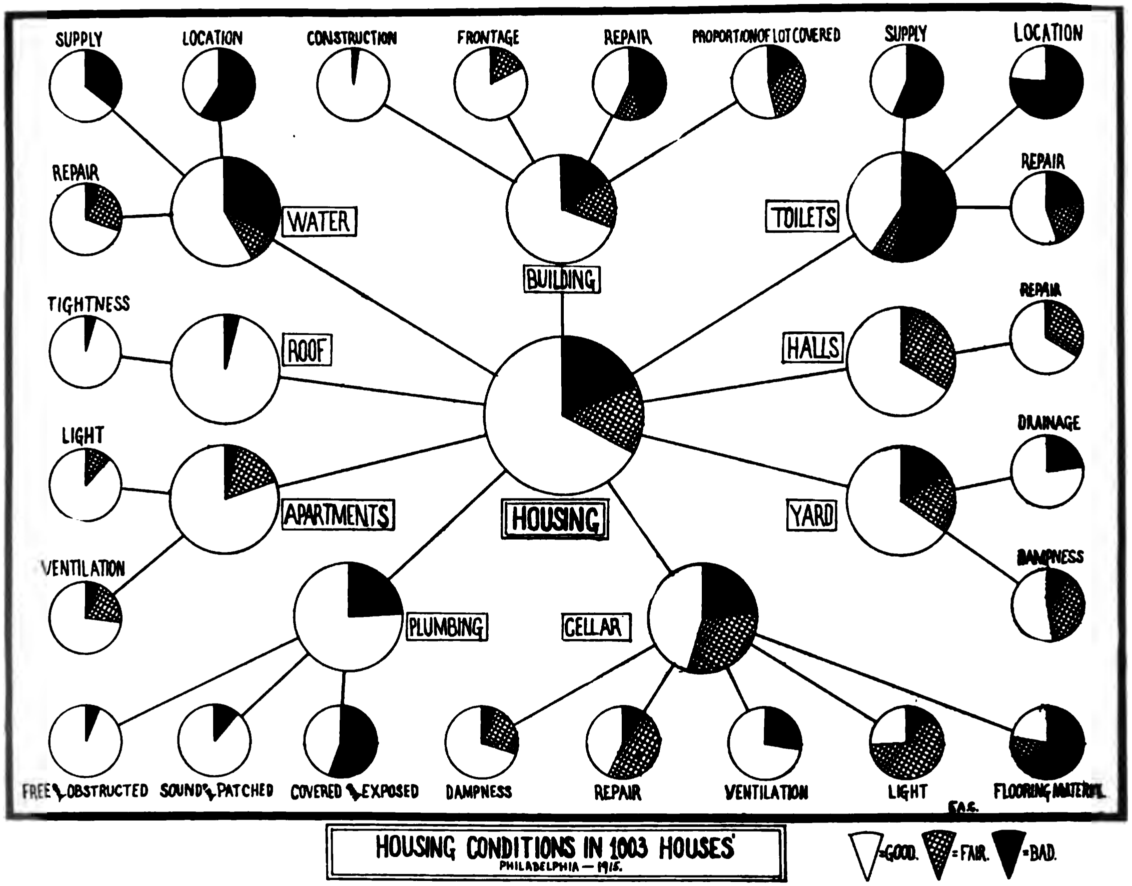


HOUSING CONDITIONS IN 1003 HOUSES
PHILADELPHIA — 1915.

portion of the lot covered by the building is a very bad feature of the house itself.

In the yards the drainage was bad,—surface drainage in a very large proportion,—and there was considerable dampness, with quite a number of wet yards. The figures in regard to plumbing, as already stated, cannot be considered very reliable. The cellars were a very bad feature, largely due to the poor flooring material and dampness, although the light, ventilation, and repair were also bad.

Under water supply the worst feature was the large proportion of fixtures found in the yards. There is some question as to whether this can be considered as a very serious defect. When it constitutes the only supply the house possesses, it should, of course, be considered bad. The next most important defect is the lack of sufficient water for the number of people, and this is a very serious defect in any house, rendering cleanliness not "next to godliness," but next to impossible.

The most serious defects found in all the investigation were in the toilet facilities, especially striking being the small number of toilets located within the house and the scarcity of toilets in proportion to the population. The large number of toilets found in bad repair was mainly due to the yard privies. According to the findings on this chart, the most important steps for the improvement of the houses, from the standpoint of the health of the community, would be some method for the suppression of the yard toilets, especially the privies, and for increasing the number of hall and room toilets; secondly, some regulation for increasing the water supply to the house, making this compulsory; thirdly, an effort should be made for improving the condition of the cellars; fourthly, a rigid enforcement of the law regulating the proportion of the lot covered by the building.

THE IMPORTANCE OF GOOD HOUSING.

The subject of housing should not be dismissed without emphasizing the extreme importance of this phase of the public health problem. It is a subject which deserves the interest and assistance of every person who gives any consideration to the health and welfare of their city. It is certainly astonishing that the confines of the home, the fundamental basis of our entire social structure, should not receive more wide-spread attention than it does—nearly all the activity in the direction of discussing the proper regulations being left in the hands of a few individuals. If this is due to a lack of knowledge, there is certainly an opportunity for a vigorous educational campaign.

There is, on the other hand, considerable attention paid the conditions in the factories and shops, probably due to the activities of the various labor unions. There can, however, be absolutely no comparison between the relative importance of the two subjects. From the standpoint of the proportion of time the total population spends in each, there can be no doubt that the house itself is the more important.

In the present investigation the following conditions were found which are fairly typical of the entire population of the city.

It was found that 32 per cent. of the entire population were children under fourteen years of age. It is a very conservative estimate to consider that one-third of them spend their entire time in and about the house—10 per cent. of the entire time of the total population. The remaining two-thirds, being school children, spend about two-fifths of their time in the house—8 per cent. of the entire time of the total population.

Among the adults there must be one housewife to each house (1003), or one-fifth of the population, who spends five-sixths of her time in and about the house—16 per cent. of the entire time of the total population. The remainder (48 per cent.), being working people, must spend at least one-third (eight hours) of their time in the house—16 per cent. of the entire time of the total population.

Combining these figures (children, 10 per cent. and 8 per cent.; housewives, 16 per cent., and workers, 16 per cent.), one finds that one-half (50 per cent.) of the entire time of the total population is spent in and around the houses. When this is compared to the 24 per cent. of the time of the total population spent in the factories and shops (allowing half a day to each of the 48 per cent. workers, an extremely high estimate), the relative importance of the house is at once apparent.

When one remembers that those spending almost their entire time in the homes are the young children and the mothers who have child-bearing to contend with, in addition to their housework, there can be absolutely no comparison between the relative importance of the workshop and the home.

THE RELATION BETWEEN HOUSING AND PUBLIC HEALTH.

It seems almost useless repetition to refer at this time to such a well-established fact as the intimate relation existing between housing and the public health. The only excuse one can offer for referring to the subject is that, in spite of the fact that it is so evident and has been so definitely proved time and again by numerous observers, this aspect of the public health question has not received the attention from the public officials that it deserves.

Without attempting to show in detail in just what manner the various common defects in housing affect the health of the tenants, we will merely call attention to the importance attached to housing by several national bodies and health officers.

At the second annual meeting of the American Association for the Study and Prevention of Infant Mortality (1911) not only was a special section devoted to Housing, but at the meeting of that section a resolution was passed in which, after referring to the fact that "bad housing conditions more directly and seriously affect the welfare of the mother and infant than any other classes in the community," it was resolved "That the Section on Housing of the American Association for Study and Prevention of Infant Mortality *hereby recommend* that every means possible be taken to enlist support for the Housing Reform Movement as vital to the purposes of this Association." Such a resolution leaves no doubt as to what that body of people thought in regard to the relation between housing and infant mortality.

There is one disease which is peculiarly associated with housing which calls for special mention, namely, tuberculosis. This is especially true as the Association formed to eradicate this disease was the pioneer which cleared the way for nearly all the later movements for the improvement of the public health, so well brought out by Biggs and Bolduan in their article—"The Tuberculosis Campaign—Its Influence on the Methods of Public Health Work Generally" (Ninth Annual Meeting of the National Association for the Study and Prevention of Tuberculosis, 1913).

The Sixth Annual Conference of the British National Association for the Prevention of Consumption and Other Forms of Tuberculosis (1914) considered housing of so much importance that "The House in Relation to Tuberculosis" was one of the three topics considered during the session. One cannot do better than to quote briefly the statements of some of the speakers at that conference: "I am sure that every one who is interested in the campaign against tuberculosis will agree that the National Association for the Prevention of Consumption could not have selected a more useful and appropriate subject for discussion at this conference than the part which the house plays in the propagation and maintenance of this disease" (Sir William Younger, Bart.). He then quotes Dr. Ditmar, Medical Inspector under the Local Government Board, who, in referring to the marked spread of consumption in the islands of the west of Scotland, says: "The main factor is the condition of the housing." He also quotes other witnesses as follows: "The problem lies in the housing conditions, and nothing else"; "I think the spread of phthisis is due to the houses."

Dr. Chalmers, Medical Health Officer of Glasgow, in referring to the fact that the tuberculosis death-rate in certain districts of the city was 200 to 600 per cent. higher than in others, said: "The house is a dominant factor in the matter."

It has been contended that tuberculosis was more prevalent in certain districts, not on account of the bad housing, but because, where bad housing was most prevalent, there one also found poverty, with all its associated evils. The results obtained in Liverpool show the fallacy of this contention.

The city of Liverpool in several districts tore down large sections of defective houses (from the standpoint of health) and erected suitable sanitary dwellings *in which practically the same people were housed who had occupied the former dwellings.* The result was that the phthisis death-rate fell in these districts from 4 per 1000 to 1.9 per thousand. The death-rate from consumption was more than cut in half by the improvement in *housing alone.*

In Edinburgh the results were more striking, but were weakened by the fact that the houses were not occupied by the same people. In that city the tearing down of bad houses and the erecting of good caused the general death-rate to fall from 45 to 15 per 1000, the phthisis death-rate from 3.8 to 0.4 per 1000, and from other tuberculous diseases from 7.1 to 0.4 per 1000. There can be no clearer evidence of the importance of the relation between housing and tuberculosis.

That what applies to tuberculosis applies equally to other diseases may be judged by the statement of Mildred Chadsey, Chief Sanitary Inspector, Health Department, Cleveland, Ohio: "Our city has prepared a set of pin maps that show where the cases of tuberculosis, contagious diseases, of gastro-intestinal diseases, of infants' deaths, and all deaths which have occurred during the year are marked. It has prepared another set of pin maps showing where the foul plumbing, the filthy yard-closets, the dark rooms, the overcrowded lots are, and in every map the pins have practically gone in the same place."

The value of the opinions of these physicians and health officers who have given the subject considerable study and the experiences of these cities must convince even the most prejudiced that, from the standpoint of public health, the housing of the population is a matter which deserves the most careful consideration.

LIVING CONDITIONS.

It has been shown that proper housing is important from the standpoints of health, morality, comfort, and safety. But a study of housing alone will not give a complete picture of the exact home conditions of the people. Any investigation of this kind is necessarily incomplete without some study of the social and economic conditions of the dwellers in the houses studied. While the latter is fairly easily determined and may be approximately exact, the social status or morale of a family is extremely difficult to gage and define. In searching for some means of expressing the social condition of a family, it was decided that cleanliness was probably the one factor which would serve as an index. This cardinal virtue has, therefore, been used as a basis for estimating the social status of each family, grading the families according to the same method adopted for grading the houses, namely, "100," "80," "60," "40," "20," and "0." The grade of each family was determined by the field worker, and, as stated, was based largely upon the cleanliness of the home. While this method permits the personal element to enter the estimation to a marked degree, this is practically unavoidable.

SOCIAL STATUS.

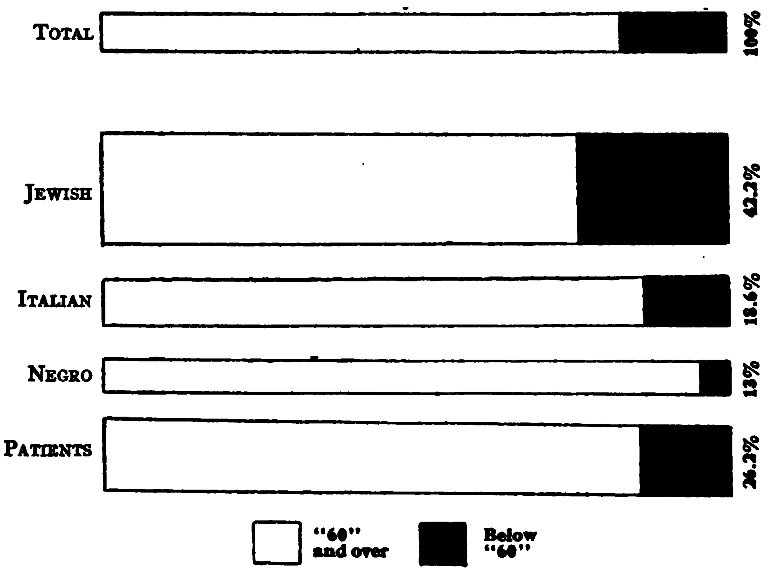
A great many people have formed definite opinions as to how different classes and races live, their opinions being frequently based upon either very superficial observation or hearsay. A study of Table 58 will tend at least to weaken some of the views held by many. That two-fifths (40.8 per cent.) of the people investigated were of such a type as to be classed by the field workers as of a social grade of "100," and only about one-fourteenth (17.1 per cent.) of a social grade of "0," gives one an entirely different view of the people in the poorer districts than the one generally held. The differences between some of the races are particularly striking. Who would have been willing to believe that about two-thirds (66.3 per cent.) of the negroes would have been graded at "100," while the Jews would have shown less than one-third (29.4 per cent.) of their number of an equal social grade? While the Italians showed less than half (48.1 per cent.) of their number of a grade of "100," they, on the other hand, showed the smallest proportion (1.1 per cent.) of a social grade of "0."

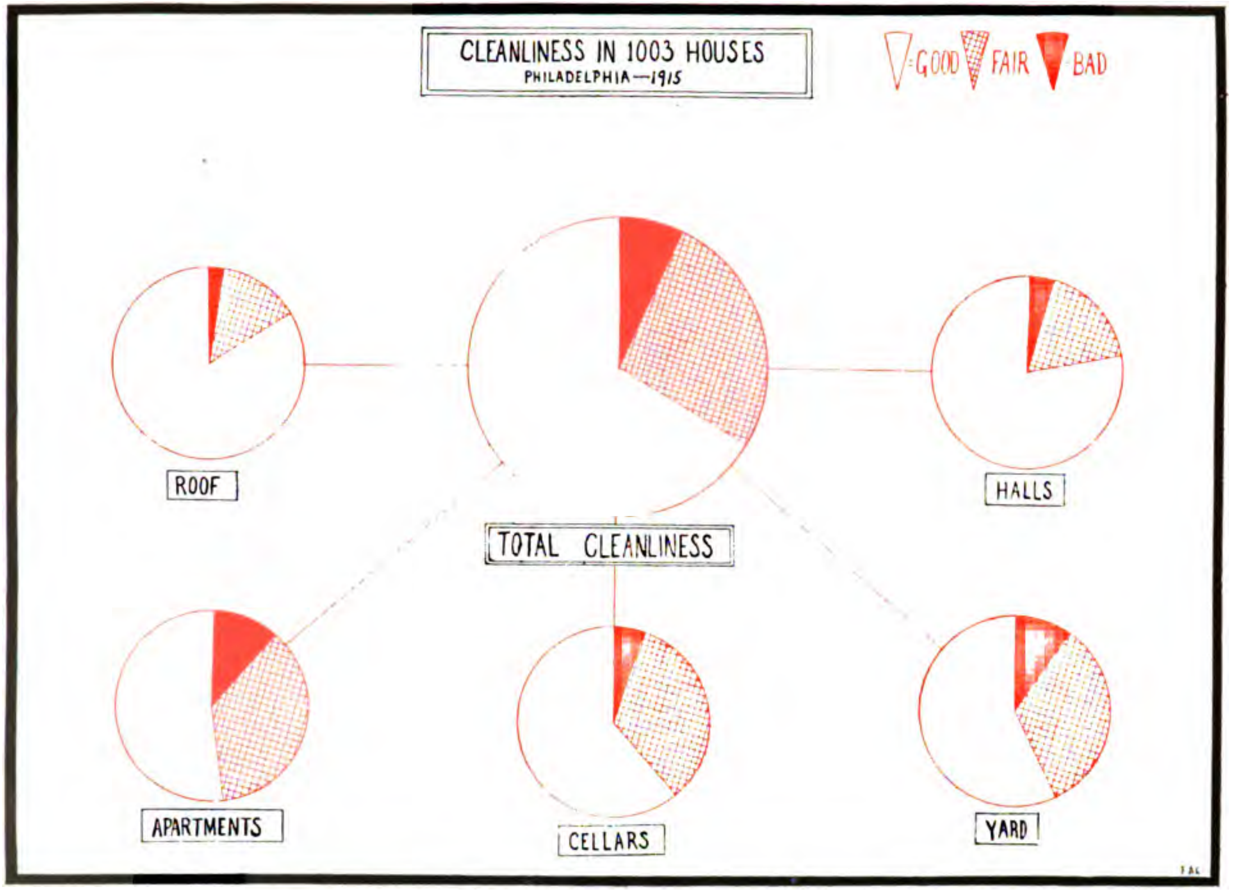
TABLE 58.—NUMBER OF PEOPLE LIVING UNDER EACH SOCIAL GRADE—BASED ON CLEANLINESS.

Social Grade	Total		Jewish		Italian		Negro		Patients	
	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.
100......	2374	40.8	720	29.4	520	48.1	500	66.3	634	41.6
80......	1836	31.6	551	22.4	402	37.2	219	29.0	664	43.5
60......	748	12.8	676	27.6	33	3.0	6	0.8	33	2.2
40......	406	7.0	239	9.7	115	10.6	0	0	52	3.4
20......	39	0.7	39	1.6	0	0	0	0	0	0
0......	411	7.1	228	9.3	12	1.1	29	3.9	142	9.3
Total...	5814	100.0	2453	100.0	1082	100.0	754	100.0	1525	100.0
Per cent.	100.0	..	42.2	..	18.6	..	13.0	..	26.2	..

GRAPHIC CHART OF TABLE 58.

PROPORTION OF PEOPLE BELOW A SOCIAL GRADE OF "60."





This chart shows the degree of cleanliness found in various parts of the house, as well as for the entire house (central circle). This chart can be used for comparison with the chart showing the entire housing (facing page 46).

That the grades represent the morale or social status of a family may be open to considerable question, but the fact that the figures represent fairly accurately the degree of cleanliness of the home must be recognized. Even if one, therefore, considers these comparisons of the races as merely indicating the degree of cleanliness, the results are equally striking.

If all those of "60" and over are considered as clean and all below "60" as dirty apartments, the negroes show by far the best conditions, with *96 per cent. of clean homes.* The Italians and patients were next, with the advantage slightly in favor of the former, and the worst conditions were found among the Jewish people, one-fifth of whom (20.6 per cent.) were living in dirty homes (below a grade of "60").

To many people who have been accustomed to think of the negro population as living to a great extent in squalid, filthy homes, the findings just given must come in the nature of a revelation. Thinking that there might be some lack of uniformity in the grading of the homes by different workers, the negro estimates being made by a colored social worker, several workers were questioned on the degree of cleanliness observed by them in the homes of different races, and they all agreed that the above percentages would conform fairly closely to their general impressions.

Several times in the preceding pages attention has been called to the fact that the conditions depending upon the people themselves, such as cleanliness, show almost invariably a better state of affairs than those conditions depending upon some one else, as the landlord, or upon money alone.

It was thought that it might prove of interest to bring together for comparison the tables showing the proportion of the population living in houses of various grades and the table showing the proportion of people living in homes of varying grades of cleanliness, or, according to the plan adopted, of varying social grades.

TABLE 59.

Proportion of People Living in Houses of Various Grades—Housing.			Proportion of People of Various Social Grades—Cleanliness.	
Grade	Number	Percentage	Number	Percentage
100	544	9.4	**2374**	**40.8**
80	1257	21.6	**1836**	**31.6**
60	2722	46.8	**748**	**12.8**
40	349	6.0	**406**	**7.0**
20	152	2.6	**39**	**0.7**
0	790	13.6	**411**	**7.1**
	5814	100.0	**5814**	**100.0**

The contrast between the housing and the social status (cleanliness) is very well shown in the graphic chart, the largest proportion of people of different social grades being in the grade of "100," while in housing the largest percentage is seen to be in the grade of "60." If cleanliness is accepted as an index of the morale or social status of the people, this table and chart alone would seem to indicate that the people are of a much higher grade than the housing. In other words, the social standard maintained by the people in their own houses is considerably higher than the houses which they are capable of renting.

It will be noted that while 40.8 per cent. of the people were living in the apartments that were scrupulously clean, there were only 9.4 per cent. of the people living in very good houses, while 13.6 per cent. of the people were living in houses that were graded at "0," only 7.1 of them lived in filthy apartments. This tends to confirm the former assertion in regard to the relation between the housing and the social status or morale of the people.

There is still another way of studying this relation, and that is by a comparison of the proportion above "60" with that of "60" and under.

It will be noted that the proportion of people living in houses above a grade of "60" (31 per cent.) is very much smaller than the proportion of people living in apartments above a cleanliness grade of "60" (72.4 per cent.), which still further confirms the former findings.

It must be borne in mind that the largest proportion of the people lived in houses graded at "60," which is just below the arbitrary dividing line of "60," while the majority of people lived in apartments that were scrupulously clean, giving them a social grade of 100. The difference between the two conditions, housing and cleanliness, is in reality, therefore, not quite so great as would appear from the study of this chart.

This brings up the question as to what is the exact relation between cleanliness and housing, whether a majority of the people of a social grade of "100" are to be found among the "100" grade houses? Is good housing conducive to cleanliness and the bad housing to filthiness on the part of the dwellers in the houses? Or, to take it from another viewpoint, do the cleanly people select good houses, and are the filthy people content with bad houses?

In an effort to throw some light upon this far from simple but exceedingly important subject, the tables on pages 55 and 56 have been prepared.

These tables are rather complicated and need some explanation. In the first are grouped the people living in each grade of house, these being subdivided according to the degree of cleanliness (heavy type). In the table it will be noted that the "100" houses have the highest proportion of

GRAPHIC CHART OF TABLE 59.

HOUSING AND CLEANLINESS.

COMPARING PROPORTION OF POPULATION IN VARIOUS GRADES OF EACH.

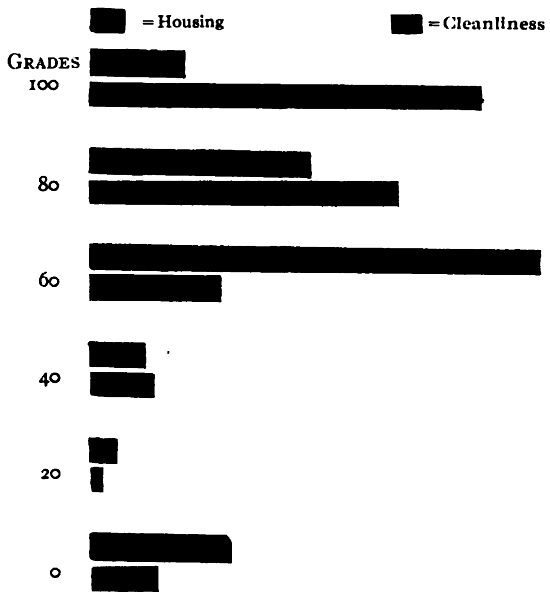


TABLE 61.—ALL DISTRICTS COMBINED—PROPORTION OF PEOPLE OF DIFFERENT GRADES OF CLEANLINESS LIVING IN HOUSES OF DIFFERENT GRADES.

HOUSING	100		80		60		40		20		0		TOTAL	
CLEANLINESS	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.
100	322	59.2	445	35.4	1128	41.4	100	28.6	25	16.4	354	44.8	2374	40.8
80	148	27.2	401	31.9	924	34.0	126	36.1	29	19.1	208	26.3	1836	31.6
60	35	6.4	216	17.2	291	10.7	48	13.8	57	37.5	101	12.8	748	12.8
40	23	4.2	122	9.7	210	7.7	27	7.7	17	11.2	7	0.9	406	7.0
20	0	0	0	0	24	0.9	0	0	12	7.9	3	0.4	39	0.7
0	16	3.0	73	5.8	145	5.3	48	13.8	12	7.9	117	14.8	411	7.1
Total	544	100.0	1257	100.0	2722	100.0	349	100.0	152	100.0	790	100.0	5814	100.0
Per cent......	9.3	..	21.6	..	46.8	..	6.1	..	2.6	..	13.6	..	100.0	..

TABLE 62.—SUMMARY OF PERCENTAGES OF TABLE 61.

Cleanliness	HOUSING GRADES		
	"100"+"80"	"60"+"40"	"20"+"0"
	Per Cent.	Per Cent.	Per Cent.
"100"+"80".............	73.1	74.1	65.4
"60"+"40".............	22.0	18.8	19.3
"20"+ "0".............	4.9	7.1	15.3
	100.0	100.0	100.0

TABLE 63.—ALL DISTRICTS COMBINED—PROPORTION OF PEOPLE LIVING IN HOUSES OF DIFFERENT GRADES OF DIFFERENT GRADES OF CLEANLINESS.

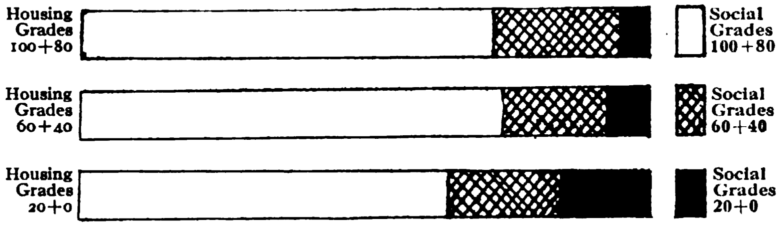
CLEANLINESS	100		80		60		40		20		0		TOTAL	
HOUSING	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.
100	322	13.6	148	8.1	35	4.7	23	5.7	0	0	16	3.9	544	9.3
80	445	18.7	401	21.8	216	28.9	122	30.0	0	0	73	17.8	1257	21.6
60	1128	47.5	924	50.3	291	38.9	210	51.7	24	61.5	145	35.3	2722	46.8
40	100	4.2	126	6.9	48	6.4	27	6.7	0	0	48	11.7	349	6.1
20	25	1.1	29	1.6	57	7.6	17	4.2	12	30.8	12	2.9	152	2.6
0	354	14.9	208	11.3	101	13.5	7	1.7	3	7.7	117	28.4	790	13.6
Total	2374	100.0	1836	100.0	748	100.0	406	100.0	39	100.0	411	100.0	5814	100.0
Per cent.	40.8	..	31.6	..	12.8	..	7.0	..	0.7	..	7.1	..	100.0	..

TABLE 64.—SUMMARY OF PERCENTAGES OF TABLE 63.

HOUSING	CLEANLINESS		
	"100"+"80"	"60"+"40"	"20"+"0"
	Per Cent.	Per Cent.	Per Cent.
"100"+"80"	31.3	34.3	19.8
"60"+"40"	54.1	50.0	48.2
"20"+ "0"	14.6	15.7	32.0
	100.0	100.0	100.0

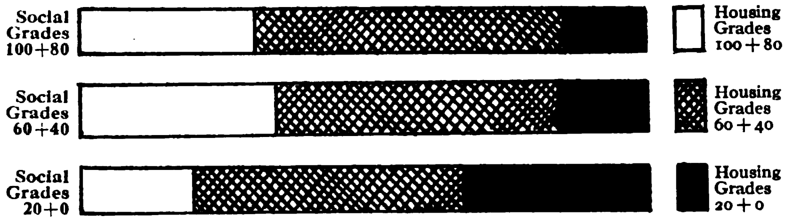
GRAPHIC CHART OF TABLE 62.

SHOWING THE SOCIAL STATUS OF THE PEOPLE LIVING IN HOUSES OF DIFFERENT GRADES.



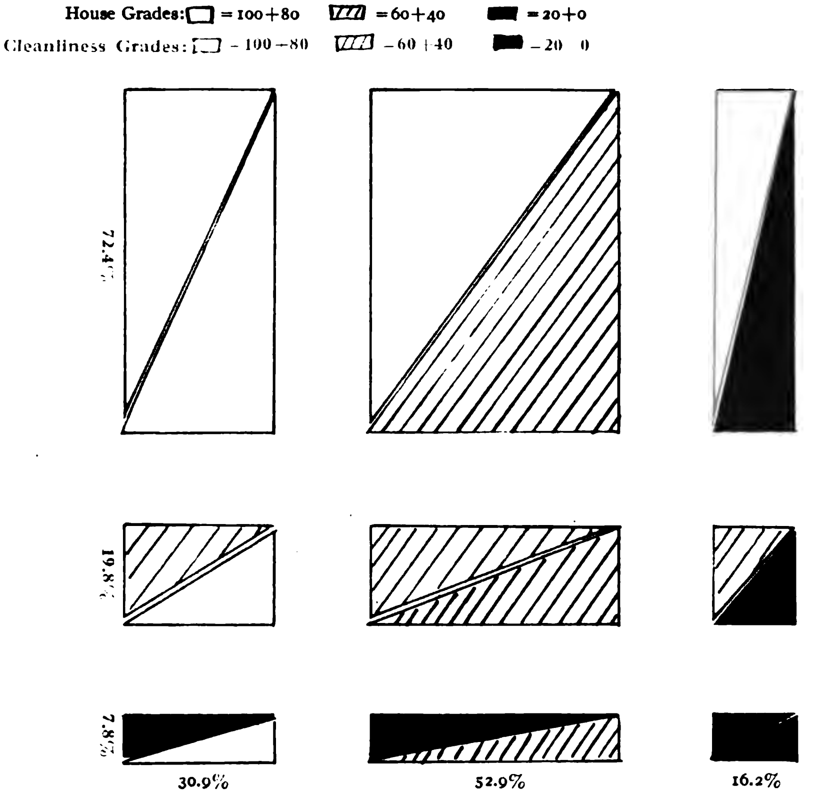
GRAPHIC CHART OF TABLE 64.

SHOWING THE HOUSING OF THE PEOPLE OF EACH SOCIAL GRADE.



GRAPHIC CHART 65.

PROPORTION OF POPULATION OF EACH GRADE OF CLEANLINESS IN EACH GRADE OF HOUSING.



"100" cleanliness, and in the "0" (or very bad) houses there is the largest proportion of "0" cleanliness (or filthiness). The summaries of Tables 61 and 63 (Tables and Charts 62 and 64) show that in the good houses ("100" and "80") 73.1 per cent. of the people are clean (grades 100 and 80), and only 4.9 per cent. are filthy. In the bad houses ("60" and "40"), while there are 74.1 per cent. clean ("100" and "80"), there are 7.1 per cent. filthy. In the very bad houses ("20" and "0"), the percentage of cleanly people has dropped to 65, and the percentage of filthy people has risen to 15.3.

How much significance one may attach to these figures is somewhat questionable, and yet the fact remains that the higher grades of houses show a greater proportion of cleanliness, and the worst houses the greatest proportion of filthiness. If one understood by good and bad houses merely houses which were higher in price, this condition would be very easily understood, but the figures do not represent anything but the healthiness of the house and cost does not enter the calculation of house grade at all. These figures seem to indicate that a good house stimulates in the people dwelling in it a greater sense of cleanliness, or that people of a certain morale or social status (indicated by their cleanliness) tend to select the better houses. The first is by far the more likely.

Tables 63 and 64 give the people of various grades of cleanliness subdivided according to the grade of house. As one would expect, the relative proportions are very similar to those found in Tables 61 and 62.

Chart 65 shows very clearly that the largest section of the people are those of cleanly habits, living in bad houses; the smallest portion of the community are filthy and live in very bad houses. The second largest group are the cleanly people living in good houses. This gives one a very different picture of the homes of the people of the class under consideration from the one commonly held.

On pages 58 and 59 are given the summaries of tables showing the relation between housing and cleanliness in the different races. The only group showing a constant and definite relation between good housing and cleanliness were the Jews, where the relation is very striking. There was nothing of special importance in the other groups except that they all showed a tendency to have the cleanliness diminish and the filthiness increase in the lower grades of houses.

TABLE 66.—SUMMARY—PROPORTION OF PEOPLE OF DIFFERENT GRADES OF CLEANLINESS LIVING IN HOUSES OF DIFFERENT GRADES—ACCORDING TO DISTRICT.

Cleanliness	Jewish								Italian							
	Housing						Total		Housing						Total	
	100–80		60–40		20–0				100–80		60–40		20–0			
	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.
100–80	543	59.7	537	48.2	191	44.6	1271	51.8	332	86.2	573	85.2	17	70.8	922	85.3
60–40	314	34.5	447	40.1	154	36.0	915	37.3	48	12.5	93	13.8	7	29.2	148	13.6
20– 0	53	5.8	131	11.7	83	19.4	267	10.9	5	1.3	7	1.0	0	0	12	1.1
Total	910	100.0	1115	100.0	428	100.0	2453	100.0	385	100.0	673	100.0	24	100.0	1082	100.0
Per cent	37.1	..	45.4	..	17.5	..	..	..	35.6	..	62.2	..	2.2	..	..	..

Cleanliness	Negro								Patients' Families							
	Housing						Total		Housing						Total	
	100–80		60–40		20–0				100–80		60–40		20–0			
	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.
100–80	69	97.2	379	98.7	271	90.6	719	95.3	372	85.5	789	87.8	137	71.7	1298	85.1
60–40	0	0	1	0.3	5	1.7	6	0.8	34	7.8	35	3.9	16	8.3	85	5.6
20– 0	2	2.8	4	1.0	23	7.7	29	3.9	29	6.7	75	8.3	38	20.0	142	9.3
Total	71	100.0	384	100.0	299	100.0	754	100.0	435	100.0	899	100.0	191	100.0	1525	100.0
Per cent	9.4	..	50.9	..	39.7	..	..	..	28.5	..	59.0	..	12.5	..	..	..

TABLE 67.—SUMMARY—PROPORTION OF PEOPLE LIVING IN HOUSES OF DIFFERENT GRADES OF DIFFERENT GRADES OF CLEANLINESS—ACCORDING TO DISTRICT.

	JEWISH								ITALIAN							
HOUSING	CLEANLINESS						TOTAL		CLEANLINESS						TOTAL	
	100–80		60–40		20–0				100–80		60–40		20–0			
	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.
100–80	543	42.7	314	34.3	53	20.0	910	37.1	332	36.0	48	32.4	5	41.7	385	35.6
60–40	537	42.3	447	48.9	131	49.0	1115	45.4	573	62.2	93	62.9	7	58.3	673	62.2
20– 0	191	15.0	154	16.8	83	31.0	428	17.5	17	1.8	7	4.7	0	0	24	2.2
Total..........	1271	100.0	915	100.0	267	100.0	2453	100.0	922	100.0	148	100.0	12	100.0	1082	100.0
Per cent.	51.8	..	37.3	..	10.9	..	..	..	85.3	..	13.6	..	1.1	..	..	..

	NEGRO								PATIENTS' FAMILIES							
HOUSING	CLEANLINESS						TOTAL		CLEANLINESS						TOTAL	
	100–80		60–40		20–0				100–80		60–40		20–0			
	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.
100–80	69	9.6	0	0	2	6.9	71	9.4	372	28.7	34	40.0	29	20.4	435	28.5
60–40	379	52.7	1	16.6	4	13.8	384	50.9	789	60.8	35	41.2	75	52.8	899	59.0
20– 0	271	37.7	5	83.4	23	79.3	299	39.7	137	10.5	16	18.8	38	26.8	191	12.5
Total..........	719	100.0	6	100.0	29	100.0	754	100.0	1298	100.0	85	100.0	142	100.0	1525	100.0
Per cent.	95.3	..	0.8	..	3.9	..	..	..	85.1	..	5.6	..	9.3	..	..	..

CROWDING.

It has been demonstrated beyond question that overcrowding of people has a very deleterious effect upon their health and also upon their morality. The prevalence of disease and crime in our large cities can be shown to bear a direct relation to the amount of overcrowding. What are the conditions peculiar to overcrowding which would account for the increase of disease and the lowering of the moral tone? The latter portion of the above question does not come within the scope of the present paper, and merely those points which seem to have a bearing upon disease will be considered.

One of the greatest factors in the causation of disease as a result of overcrowding is the lack of sufficient fresh air, and by this is understood not only air lacking in the proper amount of oxygen and containing an excessive amount of carbon dioxid, but also containing those organic substances suspended in the air, so difficult to estimate, concerning the poisonous qualities of which there still seems to be some doubt. Another factor is the facility offered to the transmission of contagious diseases from one person to another. The truth of this statement can be easily verified by the study of any of the transmissible diseases. A very good example of this is Colonel Gorgas's experience with pneumonia, epidemics of which were overcome and eradicated by removing men from crowded barracks.

There are numerous other factors so commonly and intimately associated with overcrowding that they have been looked upon as part of the problem, although they are really not dependent upon overcrowding itself, but are the results of the conditions usually associated with overcrowding. Some of these are poverty, filth, lack of food, overwork, the bearing of too many children at too frequent intervals, etc. Without considering these various factors in detail, an effort has been made to determine to what extent overcrowding existed in the districts studied, and the relation of this overcrowding to various factors.

Crowding is considered under various headings, such as the number of families per house, the number of people per house, and the number of persons per room, expressed in the number of people per 100 rooms. Of these three methods of expressing the degree of crowding, the last is the only one which gives any adequate conception of the degree of crowding, and is by far the best and most usually accepted standard for comparison.

In addition to giving the findings in the present investigation, an attempt has been made to show to what degree the crowding is affected by such important factors as, first, the number or proportion of children (below the age of fourteen years), because information in regard to this point was necessary in order to determine the exact significance of the number of people per room. Thus five people occupying two rooms would have an entirely different significance if three of them were children than if they were all adults. Second, whether there are lodgers among the number or not would have considerable bearing on the subject, and is in itself an important question, for several reasons, largely economic. Third, whether there is a store included among the rooms would have considerable bearing on the question of overcrowding, as the number of people in the apartment are compared to the number of rooms, and if stores are included among the rooms, it would give one a very false idea as to the exact living conditions present in regard to crowding. These factors, lodgers and stores, have also a very important bearing upon income and rent, which will be taken up under a separate heading.

A method of studying this question frequently employed is by expressing the number of people living in apartments of one, two, three, etc., rooms. This might give one a general idea of the existing conditions if applied to some city where it would indicate one-, two-, three-, etc., roomed houses, as, for example, in some of the foreign (Scotch and English) cities studied, but it does not apply in the present instance. Although it has very little meaning in this study, and might possibly be misleading, it has been so frequently used that the findings have been tabulated according to this method simply for comparison (Table 68).

In Table 69, showing the number of houses with the number of rooms in each, it will be seen that the six-room house was the most numerous, occurring 80 times. It will also be noted that in the Jewish district the large houses with a great many rooms (as high as 24 rooms) occurred more frequently than in the other districts. The highest number of rooms in one house in the Italian district was 13, and in the negro district, 16. This accounts for the high average in the Jewish district of 7.2 rooms per house. The above brings out the fact that the large tenement houses are not common in the districts examined, and this can be said of the city as a whole. This subject has been dealt with in detail by Helen L. Parrish in her article, "One Million People in Small Houses" (National Housing Association Publication No. 7).

In considering many of the different subjects taken up in this second section no reference is made to the patients' homes and families. This is because the data collected in the patients' homes were not found to be in such shape as to be available for some of the studies.

TABLE 68.—NUMBER OF ROOMS OCCUPIED BY EACH FAMILY.

NUMBER OF ROOMS	I		II		III		IV		V		VI		VII		VIII		IX		X		XI		XII		XIII		TOTAL	
	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.
Italian families	38	15.0	82	32.2	41	16.1	27	10.0	24	9.5	17	6.7	14	5.6	7	2.8	2	0.7	2	0.7	0	0	0	0	0	0	254	100.0
Negro families	86	40.0	10	4.6	24	11.2	24	11.2	20	9.3	18	8.4	15	6.9	6	2.8	6	2.8	1	0.5	2	0.9	3	1.4	0	0	215	100.0
Jewish families	82	14.0	94	16.0	69	28.9	97	16.6	42	7.2	40	6.9	29	5.0	17	2.9	4	0.6	6	1.2	1	0.1	3	0.5	1	0.1	585	100.0
Total families	206	19.5	186	17.7	234	22.2	148	14.4	86	8.1	75	7.1	58	5.5	30	2.8	12	1.1	9	0.8	3	0.2	6	0.5	1	0.1	1054	100.0

TABLE 69.—NUMBER OF ROOMS PER HOUSE.

Rooms Per House	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI	XVII	XVIII	XIX	XX	XXI	XXII	XXIII	XXIV	Total
Jewish:																									
Times occurring....	0	3	23	24	15	24	13	16	12	12	9	3	2	2	3	4	0	2	0	2	0	0	0	1	170 { Average: 7.2 rooms per house—Min. 2; max. 24.
Per cent.........	0	1.8	13.5	14.1	8.8	14.1	7.6	9.4	7.0	7.0	5.3	1.8	1.2	1.2	1.8	2.4	0	1.2	0	1.2	0	0	0	0.6	
Italian:																									
Times occurring....	1	3	13	11	15	31	20	15	9	5	1	0	1	..	..	..	..	..	..	..	..	..	..	..	125 { Average: 6.1 rooms per house—Min. 1; max. 13.
Per cent.........	0.8	2.4	10.4	8.8	12.0	24.8	16.0	12.0	7.2	4.0	0.8	0	0.8	..	..	..	..	..	..	..	..	..	..	..	
Negro:																									
Times occurring....	1	3	13	22	20	25	16	10	10	4	2	2	1	0	0	1	..	..	..	..	..	..	..	..	130 { Average: 6.0 rooms per house—Min. 1; max. 16.
Per cent..........	0.8	2.3	10.0	16.9	15.4	19.2	12.3	7.7	7.7	3.1	1.5	1.5	0.8	0	0	0.8	..	..	..	..	..	..	..	..	
Total:																									
Times occurring .	2	9	49	57	50	80	49	41	31	21	12	5	4	2	3	5	0	2	0	2	0	0	0	1	425 { Average: 6.5 rooms per house—Min. 1; max. 24.
Per cent.......	0.5	2.1	11.5	13.4	11.8	18.8	11.5	9.6	7.3	5.0	2.9	1.2	0.9	0.4	0.7	1.2	0	0.4	0	0.4	0	0	0	0.2	

TABLE 70.—NUMBER OF PEOPLE PER HOUSE.

People per House	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI	XVII	XVIII	XIX	XX and over	Total	
Jewish:																						
Times occurring.	1	9	9	19	12	18	20	7	10	8	9	6	7	4	4	1	7	3	2	14	170	Average: 9.6 people per house. Max. 39.
Per cent. .	0.6	5.3	5.3	11.1	7.0	10.6	11.7	4.1	5.8	4.7	5.3	3.5	4.1	2.4	2.4	0.6	4.1	1.8	1.2	8.4		
Italian																						
Times occurring.	0	4	7	6	5	18	13	8	10	8	10	12	5	5	3	4	0	1	1	5	125	Average: 9.3 people per house. Max. 34.
Per cent. .	0	3.2	5.6	4.8	4.0	14.4	10.4	6.4	8.0	6.4	8.0	9.6	4.0	4.0	2.4	3.2	0	0.8	0.8	4.0		
Negro:																						
Times occurring.	4	18	23	14	12	21	8	9	3	6	3	2	2	1	0	0	3	1	..	..	130	Average: 5.6 people per house. Max. 18.
Per cent. .	3.1	13.8	18.1	10.5	9.2	16.1	6.2	6.9	2.3	4.6	2.3	1.5	1.5	0.8	0	0	2.3	0.8	..	..		
Total:																						
Times occurring.	5	31	39	39	29	57	41	24	23	22	22	20	14	10	7	5	10	5	3	19	425	Average: 8.3 people per house. Max. 39.
Per cent. .	1.2	7.4	9.2	9.2	6.9	13.4	9.6	5.7	5.5	5.2	5.2	4.8	3.3	2.4	1.7	1.2	2.4	1.2	0.6	3.8		

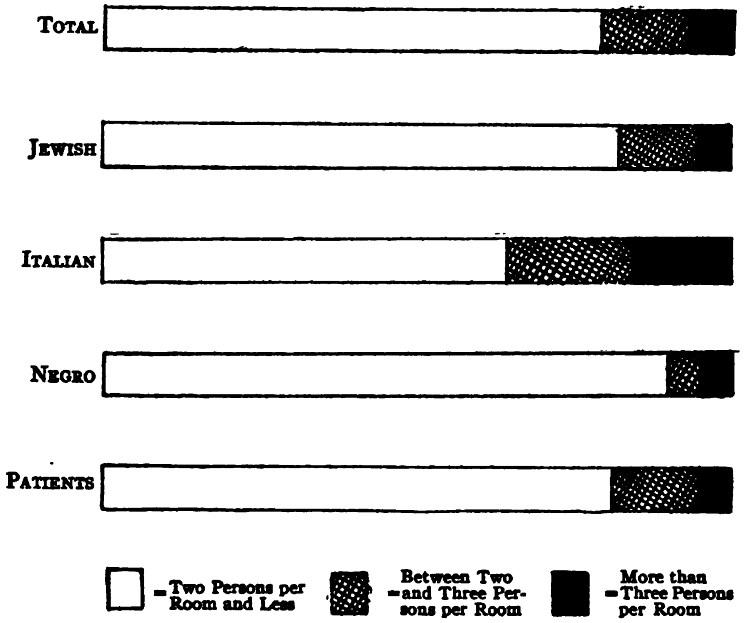
The above table gives an approximate idea of the degree of overcrowding in the districts studied. The number of people per house in the entire city was estimated a few years ago (Helen L. Parrish, 1913) at 4.7 persons per house. The only district coming anywhere near this average is the negro district, which has 5.6 persons per house, the other two being about double the general average for the city. As the negroes and Italians averaged almost the same number of rooms per house, the people per house in these two districts form a very striking contrast. All of the material collected was not available for the preparation of the above table, so another table has been prepared showing the amount of overcrowding in a different manner.

TABLE 71.—NUMBER AND PROPORTION OF POPULATION LIVING UNDER VARIOUS DEGREES OF CROWDING.

Persons per 100 Rooms	Total		Jewish		Italian		Negro		Patients' Families	
	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.
Over 300	427	7.2	139	5.4	178	15.2	38	5.0	72	4.9
201 to 300	833	14.0	332	13.0	238	20.3	50	6.6	213	14.5
151 to 200	1451	24.3	706	27.5	235	20.1	113	14.8	397	27.1
150 and under	3251	54.5	1385	54.1	520	44.4	561	73.6	785	53.5
Total	5962	100.0	2562	100.0	1171	100.0	762	100.0	1467	100.0
Percentage	100.0	..	43.0	..	19.6	..	12.7	..	24.6	..
Average persons per room	1.28		1.30		1.49		0.91		1.36	

GRAPHIC CHART OF TABLE 71.

PROPORTION OF POPULATION LIVING UNDER VARIOUS DEGREES OF CROWDING.



The difficulty in all investigations of this kind is to determine what constitutes overcrowding—how many people to a room shall be considered as the dividing line. It is only natural that this uncertainty should be felt in regard to this question. The deleterious effects of many people living in one room are dependent upon so many other factors, as size of rooms, number of sleeping rooms, window space, ventilation, etc., that no very definite conclusions can be based on the number per room alone. It must be apparent that where there are more than two people to every room, not just sleeping rooms, but every room for living, cooking, and sleeping, that house is overcrowded.

Taking this very arbitrary standard of two to a room as constituting overcrowding, the above table shows that over one-fifth (21.2 per cent.) of the people are living in this condition, with 7.2 per cent. living three in a room. The conditions in the different districts examined varied very much in the proportion of people living in overcrowded quarters. The Jewish district and the patients' families were found to follow very closely the general average; a very striking contrast was found between the Italians and the negroes, the former having 35.5 per cent. living under conditions of more than two persons to a room, while the latter had only 11.6 per cent.

How may one account for this very great difference in these different districts? There are several factors which must be considered as having some bearing on this subject which can be applied to the above figures, namely, lodgers, stores, and children.

TABLE 72.—PROPORTION OF LODGERS, CHILDREN, AND STORES.

	Total	Jewish	Italian	Negro	Patients
Average people per room	1.28	1.30	1.49	0.91	1.36
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Proportion of lodgers....	12.3	8.7	13.7	25.1	10.6
Proportion of people under fourteen years of age...	32.9	35.9	36.2	10.1	37.0
Proportion of people living in apartments with stores.................	5.5	8.2	5.8	..*	3.6

* Omitted, as there were only two stores of which we had information bearing on this point.

The above table (72) presents a few important facts which are very marked, and at the same time *apparently* tend to disprove some of the generally accepted theories in regard to the overcrowding problem. A great deal has been written in regard to the influence of the lodger evil as a cause for overcrowding, and yet the negroes who showed the least overcrowding had by far the highest proportion of lodgers. This may be explained in several ways, and is certainly more apparent than real.

TABLE 73.—AVERAGE NUMBER OF PERSONS PER ROOM, SHOWING INFLUENCE OF STORES AND LODGERS.

		Total	Jewish	Italian	Negro	Patients
Total, including stores and lodgers		1.28	1.30	1.49	0.91	1.36
No stores and no lodgers		1.25	1.24	1.43	0.93	1.35
No lodgers	Stores	1.06	1.01	1.06	..*	1.31
	No stores	1.31*	1.24	1.43	..*	1.35
No stores	Lodgers	1.38	1.66	1.76	0.89	1.37
	No lodgers	1.25	1.24	1.43	0.93	1.35

* Negroes omitted, as there were only two stores of which we had information bearing on this point.

In the first place, one must define clearly what is meant by "lodgers." Does the term include those who rent a room where they sleep at night, usually working out during the day? This is the mode of life of so many of the negroes that it is probably this type of lodgers which increases their proportion of lodgers so much, and at the same time tends to bring down the average persons per room, as they each have a room of their own. What is generally meant by the term lodger is where the family renting the apartment sublet one or several rooms to many lodgers, constituting an entirely different state of affairs from that found among the negroes, not only in its effect upon overcrowding, but upon the home life generally. At first glance the point which would seem to play the most important part in reducing the number of persons per room among the negroes is the comparatively small number of children. The relatively small proportion of children found among the negroes (only 10.1 per cent.) might possibly account for the apparent good condition of the negroes as far as overcrowding is concerned. In other words, the other districts had over one-third of their population made up of children, which might account for their apparent overcrowding. With the object of throwing some light on the subject, an estimation has been made of the number of people per room, considering, for the purpose of analysis, two children as equal to one adult (over fourteen years of age). According to this plan one finds the following number of persons per room:

TABLE 74.—RELATION OF CHILDREN TO OVERCROWDING.

	TOTAL	JEWISH	ITALIAN	NEGRO	PATIENTS
Average number of persons per room	1.28	1.30	1.49	0.91	1.36
Estimated average number of persons per room counting two children as equal to one adult	1.07	1.07	1.22	0.87	1.10

While this brings the average people per room for each district closer to the negro district, it still leaves the negro district in by far the best condition as regards crowding, and the Italian in the worst. This would seem to indicate that there must be some other explanation for the lack of overcrowding among the negroes than the small proportion of children.

In a recent publication by the Whittier Center of Philadelphia Mr. Bernard J. Newman, Secretary of the Philadelphia Housing Commission, found among the better class (the saving class) of negroes in this city that they averaged 0.8 person per room, which is only slightly better than in the present investigation (0.91). From this it would appear that the negro districts selected stood fairly high as far as negro quarters go, although they were supposed to be simply fairly average districts.

One curious feature is that the average for all the districts examined (1.28 persons per room) is exactly the same as that obtained in the investigation of selected districts of Chicago several years ago (Tenement Conditions in Chicago, City Homes Association, 1901). As to whether any significance can be attached to the crowding among the patients, as far as it might have a bearing upon their disease, it is impossible to say without more definite information.

INFLUENCE OF STORES AND LODGERS UPON CROWDING.

The two factors which might influence crowding are first the presence or absence of lodgers, and, secondly, the presence or absence of stores.

In order to see what the crowding conditions would be if both of these factors were eliminated, Tables 75A and 75B have been prepared.

The elimination of the stores and lodgers has very little effect upon the proportion of the total population living over two persons per room, but some changes are noted in the different districts.

The Jewish district shows an improvement—the proportion of people living more than two to a room drops from 18.4 per cent. to 15.1 per cent.

TABLE 75A.—NUMBER OF PERSONS PER ROOM, INCLUDING STORES AND LODGERS.

Number of Persons per Room	Total		Jewish		Italian		Negro		Patients' Families	
	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.
Over two...	1260	21.2	471	18.4	416	35.5	88	11.6	285	19.4
Two and under....	4702	78.8	2091	81.6	755	64.5	674	88.4	1182	80.6
	5962	100.0	2562	100.0	1171	100.0	762	100.0	1467	100.0

TABLE 75B.—NUMBER OF PERSONS PER ROOM, OMITTING STORES AND LODGERS.

Number of Persons per Room	Total		Jewish		Italian		Negro		Patients' Families	
	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.	Number	Per Cent.
Over two...	764	20.4	261	15.1	246	34.4	63	15.3	194	21.2
Two and under....	2985	79.6	1446	84.9	470	65.6	348	84.7	721	78.8
	3749	100.0	1707	100.0	716	100.0	411	100.0	915	100.0

The Italians remain about the same, but the negroes show an increase in the proportion of people living more than two to a room of nearly 4 per cent. (11.6 per cent. to 15.3 per cent.). Curiously, this change in the conditions among the negroes is due almost entirely to the elimination of lodgers, as there were only two stores among the negroes that are considered in this special study.

In order to see what effect the stores have upon the crowding the table in which stores and lodgers are eliminated (75B) is used as a basis for comparison. In the column to the left of the percentages in the above table have been placed the percentages of the population (over two per room, and two per room and under) who were living in rooms which included stores, the lodgers being entirely eliminated.

TABLE 76.—NUMBER OF PERSONS PER ROOM, OMITTING LODGERS, SHOWING INFLUENCE OF STORES.

Number of Persons per Room	Total		Jewish		Italian		Patients	
	Stores Per Cent.	No Stores Per Cent.	Stores Per Cent.	No Stores Per Cent.	Stores Per Cent.	No Stores Per Cent.	Stores Per Cent.	No Stores Per Cent.
Over two.....	16.6	20.4	4.8	15.3	28.1	34.4	34.2	21.2
Two and under	83.4	79.6	95.2	84.7	71.9	65.6	65.8	78.8
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Negroes omitted as there were only two stores of which we had information bearing on this point.

It will be noticed in this table that those *with stores*, in the combined districts, show less crowding. The proportion of population living with more than two people per room dropped from 20.4 per cent. to 16.6 per cent. This is very easily understood when one appreciates that where stores existed they constituted an extra room, which, while not being occupied for living purposes, was included in the estimation of the people per room. This improvement where stores existed was very marked among the Jews and to a less degree among the Italians. Among the patients, however, it was just the reverse, there being much more crowding where stores existed. It seems impossible to explain this very curious finding among the patients.

In the same way that the stores have been studied a chart has been prepared showing the effect of lodgers upon the crowding.

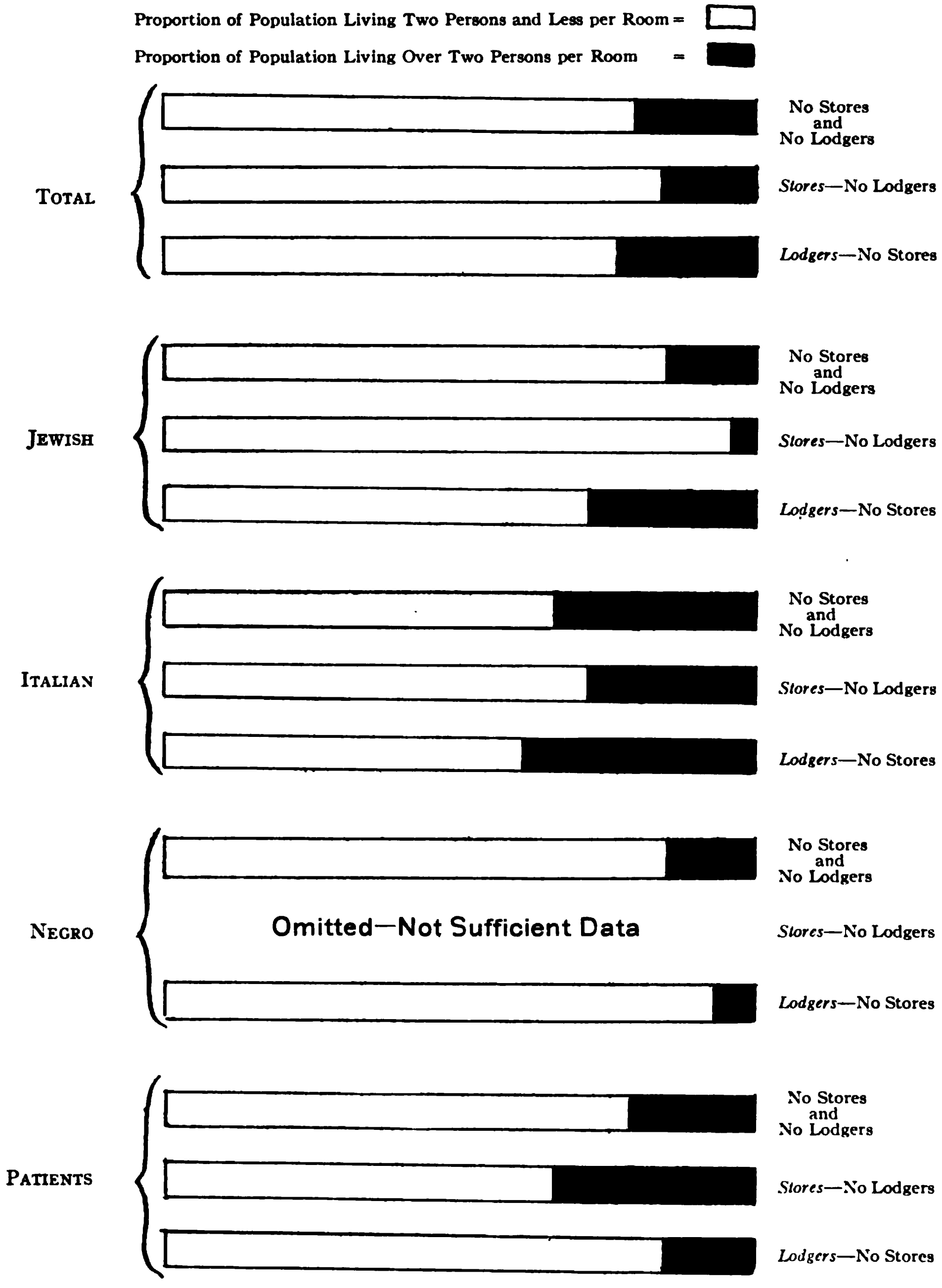
TABLE 77.—NUMBER OF PERSONS PER ROOM, OMITTING STORES, SHOWING INFLUENCE OF LODGERS.

Number of Persons per Room	Total		Jewish		Italian		Negro		Patients	
	Lodgers	No Lodgers	Lodgers	No Lodgers	Lodgers	No Lodgers	Lodgers	No Lodgers	Lodgers	No Lodgers
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Over two.......	23.1	20.4	28.0	15.3	39.3	34.4	7.1	15.3	15.6	21.2
Two and under	76.9	79.6	72.0	84.7	60.7	65.6	92.9	84.7	84.4	78.8
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

The influence of the lodgers upon the total population studied is quite distinct, causing a greater proportion of people living in rooms with more

GRAPHIC CHART OF TABLES 76 AND 77

EFFECTS OF STORES AND LODGERS UPON CROWDING



than two people per room. When one studies the different districts, some very peculiar phenomena are noted. Among the Jews, the lodgers increased the proportion of people living more than two persons per room from 15.3 per cent. to 28 per cent. The same state of affairs was noted among the Italians, but to a much less degree (increasing overcrowding only about 5 per cent.). On the other hand, just the reverse was found among the negroes and patients. It is possible to explain the findings among the negroes, owing to the type of lodger usually found among their race, as previously stated, but no explanation is offered for this rather curious finding among the patients.

The relation between crowding and lodgers and stores as noted above is illustrated in the graphic chart facing page 70.

RENT.

The high rents in certain parts of the city are due to many factors, probably the most important of which is the desire on the part of the people to be located near their places of work. This desire is due not so much to their wishing to avoid paying for transportation to and from work as it is to a desire to avoid losing the time. Even if it were possible for them to obtain rents in other parts of the city so much lower as to make up for the carfare necessary to carry them to and from their work, they could not obtain rents which would be so much lower than the more central portion of the city as to make up the carfare plus the wages lost during the time spent going to and from work. There is another factor which accounts for this congestion in certain portions of the city, and that is race community spirit or the natural tendency for foreigners to congregate in certain localities.

In a study of the question of rent the points just mentioned must be borne in mind, as well as the fact that the means of so many of these people permit them to secure only a few rooms, the renting of an entire house being usually impossible with their income. When they do rent an entire house they are frequently forced to take lodgers to make up the deficit. This leaves them, so far as their living conditions are concerned, in exactly the same position as if they had rented a portion of a house with the additional responsibility of the rent.

Home Ownership.

Before considering the subject of rent, a very important point to be determined is the number of people who own their homes.

It was found to be impossible to obtain any information from the owners in regard to what they paid for the houses, whether they were free of debt or mortgaged, and if the latter, the amount of mortgage and the rate of interest. Many of them paid for their houses in the form of monthly payments, just as they would pay rent, not taking title until a certain proportion of the entire amount had been paid.

The number of owners of homes is probably the best index of the saving abilities or thrift of any group of people. It is, therefore, of considerable interest to note the proportion of owners in the various districts studied.

TABLE 78.—NUMBER AND PERCENTAGE OF FAMILIES OWNING HOMES ACCORDING TO RACE.

Race	Total Number of Families	Number of Families Owning Homes	Percentage of Families Owning Homes
Jewish.......	538	23	4.27, or one family in every 23
Italian......	256	46	14.06, or " " " " 7
Negro.......	277	4	1.44, or " " " " 69
Total........	1071	73	6.81, or " " " " 14

The table given above confirms the general impression that the Italians are probably one of the most thrifty races that come to this country. The large proportion of Italian house owners (14.06 per cent.) being in striking contrast to the conditions among the negroes, where only 1.44 per cent. were found owning their houses. Even the Jews showed nowhere near the same proportion of house-owners as the Italians. This is a very significant table, and suggests a promising field for further study.

Another point of considerable interest is to determine what is the relation, if any, between house ownership and housing. For example: Do the owners live in better houses than the average of the race or are they forced to buy houses of inferior grade? Does ownership carry with it a demand for better housing, and the pride of ownership bring about the desire and ability to maintain the house in good condition?

Of the three districts in which definite information was obtained in regard to this point, the Italians had not only the largest proportion of owners, as previously noted, but they had also the smallest proportion of very bad houses (2.2 per cent.). The negroes had the largest proportion of houses above "60," but the number of owners was so small (only 4) that very little significance can be attached to the figures of this race in regard to this point. Compare for a moment the house grading of the owners with the house grading for the entire group (Table 1), and one finds that the Jewish owners had 21.1 per cent. more good houses (above "60") than all the Jewish combined. The Italians were more nearly the same, the owners only having 11.9 per cent. more good houses. While the number of negro owners is too small to have any real significance, it is still suggestive to note that the owners showed over 40 per cent. more good houses than the entire negro group.

TABLE 79.—NUMBER AND PERCENTAGE OF FAMILIES OWNING HOMES OF EACH GRADE OF HOUSE.

House Grade	Total		Jewish		Italian		Negroes	
	No.	Per Cent.	No.	Per Cent.	No.	Per Cent.	No.	Per Cent.
100	16	21.9	7	30.4	7	15.2	2	50.0
80	15	20.5	4	17.4	11	23.9	0	0
60	37	50.7	9	39.1	27	58.7	1	25.0
40	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0
0	5	6.9	3	13.1	1	2.2	1	25.0
Total	73	100.0	23	100.0	46	100.0	4	100.0
Per cent	100.0	..	31.5	..	63.0	..	5.5	..

TABLE 80.—SUMMARY OF PERCENTAGES OF TABLE 79.

House Grading	Total	Jewish	Italian	Negroes
Over "60"	42.4	47.8	39.1	50.0
"60" and under	57.6	52.2	60.9	50.0
	100.0	100.0	100.0	100.0

Accepting the information obtained by this investigation as correct, one is forced to the conclusion that ownership of the home is a very potent factor in the securing of good housing. This may simply mean that if the demand for homes is sufficiently great and the demand is for good houses, the quality of the houses will improve to meet the demand. Or it may mean that where houses are owned by the tenants they are kept in a better state of repair.

Whichever view one takes in regard to the significance of the facts just presented, it is apparent that the letting or renting of houses has a very bad influence upon the standard of housing, and one which should be taken into account in any study of this subject. Why would it not be possible to have some regulation by the health authorities of houses offered for rent or sale, instead of only over those in process of erection. It would certainly be a most stupendous undertaking, but not an impossible one, to insist upon the obtaining of a permit from the health authorities when one wished to rent or sell a house, just as one has to secure a permit to build a house at the present time. Why are people allowed to offer for rent or sale houses which do not comply with the building regulations as they stand at present? This recording of houses for rent or sale would bring under the control of the health authorities a large number of houses which might otherwise never be brought to their notice except by a complaint of a tenant or neighbor or by a house-to-house investigation. In this way the health or building regulations would reach those houses which, according to this investigation at least, stand in greatest need of supervision and regulation.

In any investigation of this kind a very surprising and encouraging feature is the coöperation rendered the field workers by the people themselves. The people seem ready and willing in the large majority of instances to give every assistance, especially when the workers are tactful in their methods of gaining admission to the home. In confirmation of this note the remarkably small number of dwellings in the Italian and Jewish districts colored pink on the housing maps facing page 10. The negro maps cannot be considered from this standpoint, as the colored social worker would not be expected to gain admission to the houses occupied by whites. This willingness to assist is usually very evident, until one approaches the questions relating to finances, when the people are apt to become suspicious and give evasive and indefinite answers to the questions of the workers. This tendency to secrecy in regard to financial matters is not confined to or peculiar to the class of people under investigation, but is fairly universal.

The figures in the present study bearing upon rent and income, therefore, represent considerable perseverance and tact on the part of the field workers, and no part of this investigation so well demonstrates the excellent and thorough manner in which the field work was performed as the large number of families in regard to which reliable information was obtained concerning rent and income. Too much cannot be said in praise of the very efficient manner in which the field work was performed, and no better opportunity could present itself for expressing our sense of appreciation and thanks to the social service workers who performed this part of the work. The obtaining of reliable information upon questions of finance can certainly be considered the crucial test of the social worker's capacity and fitness for the work.

RELATION BETWEEN RENT AND NUMBER OF ROOMS, NATIONALITY, GRADE OF HOUSE, STORES, AND LIVING APARTMENTS.

Rent is considered under several headings, as it was decided that the results would have very little significance if living apartments and stores were included in the same group. In order to determine whether the rent of the apartments and stores when leased from the owner (with the owner living in the same house) differed from the rent when leased from a landlord, the rent paid the owners for both living apartments and stores was placed in a separate table.

The tables given below are based upon the figures obtained from 472 Jewish, 189 Italians, and 259 negro families—920 families in all.

TABLE 81A.—AVERAGE RENT PER MONTH PER ROOM ACCORDING TO NUMBER OF ROOMS PER APARTMENT. NO OWNERS.

JEWISH.

NUMBER OF ROOMS	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	TOTAL
Without stores:													
Number of apartments	7	88	144	63	19	17	5	3	0	0	0	0	346
Average per room per month.....	$4.75	$3.22	$2.71	$2.56	$2.41	$2.11	$2.18	$2.33	..	..	..	..	..
With stores:													
Number of apartments	0	5	14	17	11	10	8	3	1	2	0	1	72
Average per room per month.....	..	$13.40	$6.26	$4.56	$4.35	$5.43	$4.18	$2.75	$3.00	$4.25	..	$4.16	..

ITALIAN.

NUMBER OF ROOMS	I	II	III	IV	V	VI	VII	VIII	TOTAL
Without stores:									
Number of apartments...........	20	39	31	15	6	8	3	2	124
Average per room per month...........	$5.25	$3.21	$2.72	$2.29	$1.90	$1.83	$2.38	$1.56	..
With stores:									
Number of apartments...........	3	4	1	2	3	1	1	3	18
Average per room per month...........	$12.00	$6.43	$10.00	$3.87	$6.40	$6.33	$3.57	$4.62	..

TABLE 81A—CONTINUED.

NEGRO.													
NUMBER OF ROOMS	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	TOTAL
Without stores:													
Number of apartments........	126	16	24	24	20	19	14	7	6	1	1	1	259
Average per room per month....	$3.11	$2.46	$2.55	$2.94	$2.70	$3.37	$2.96	$2.87	$3.61	$2.50	$3.18	$3.33	..

Number of stores too small to consider.

TABLE 81B.—AVERAGE RENT PER MONTH PER ROOM ACCORDING TO NUMBER OF ROOMS PER APARTMENT. OWNERS.

	JEWISH.						ITALIAN.					
NUMBER OF ROOMS	I	II	III	IV	V	TOTAL	I	II	III	IV	V	TOTAL
Without stores:												
Number of apartments.........	3	19	16	11	1	50	8	30	1	0	0	39
Average per room per month.....	$5.66	$3.71	$3.05	$2.84	$3.40	..	$4.18	$3.34	$3.00	..	..	..
With stores:												
Number of apartments.........	0	0	1	3	0	4	4	2	0	1	1	8
Average per room per month.....	..	..	$7.66	$5.25	..	..	$8.25	$4.37	..	$7.00	$8.60	..

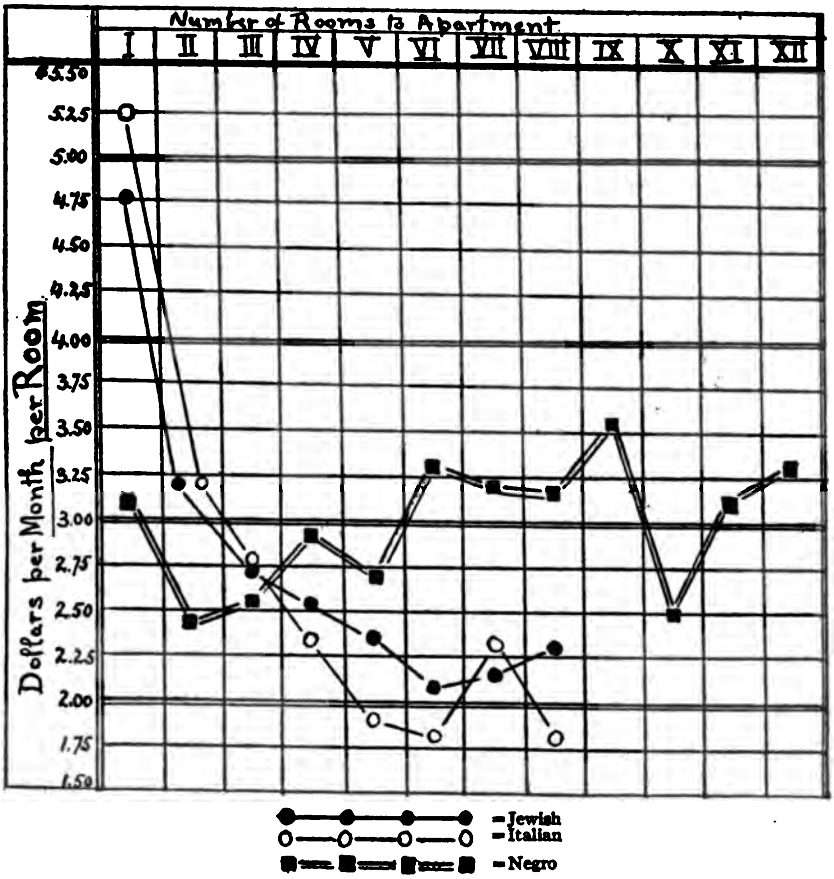
Number of owners too small among the negroes to consider.

The figures show in dollars and cents the *average cost of each room per month*, the average being based upon the rents paid by 346 Jewish, 124 Italian, and 259 negro families—729 families in all. The rents have been arranged according to the number of rooms in the apartments reduced to the common basis of *one room*. The number of rents upon which each average is based is given in the preceding table. Graphic Chart 82 is based upon the data in the above table referring to living apartments without stores.

Number of Rooms.—The chart shows in a striking way the very high rates paid by the Italians and Jews when they occupy but one room, and how the rates per room gradually fall as the number of rooms in the apartment or house increases. This explains why so many are willing to take entire houses or large apartments, for each room of which they pay rela-

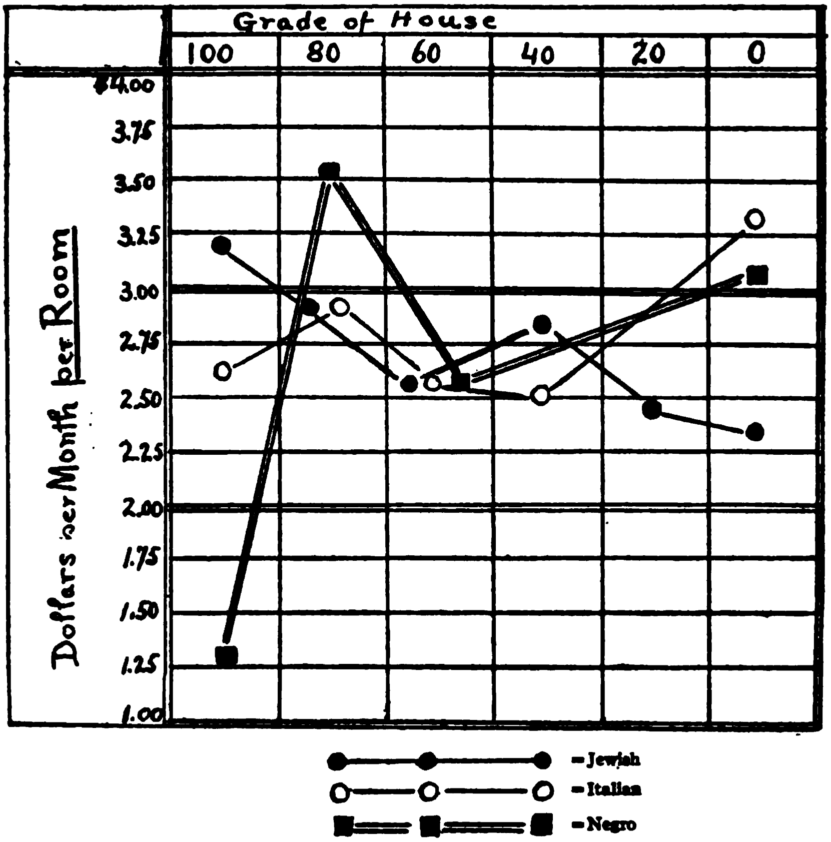
GRAPHIC CHART 82.

AVERAGE RENT PER MONTH—ACCORDING TO NUMBER OF ROOMS—OMITTING STORES AND OWNERS.



GRAPHIC CHART 83.

AVERAGE RENT PER MONTH—ACCORDING TO GRADE OF HOUSE—OMITTING STORES AND OWNERS.



tively small amounts, and then sublet the single rooms at the very high rates usually paid.

Nationality and Grade of House.—Another point which is brought out by this chart is the exploitation of the negroes in regard to the amount of rent they pay. While the rate for single rooms is not nearly as high as either the Italians or Jews, this rate remains practically stationary and does not diminish as the number of rooms increases. Notwithstanding the very inferior housing they have been shown to receive, the rates are distinctly higher than the other two groups as soon as their apartments exceed three rooms. Why this almost constantly high rate should be charged the negroes is very hard to explain unless it is demanded with the object of compensating the owners for the deterioration in value of the property which the leasing by negroes involves.

A very important point to determine is whether the character of the home, from the standpoint of health, bears any relation to the amount of rent paid. In order to determine this point Graphic Chart 83 has been prepared.

The only race in which the grade of the house, according to the system adopted, seems to have any effect upon the rent per month per room is in the case of the Jews, where the price is distinctly higher in the better houses and falls gradually (with one exception) as the grade of the houses decreases. The other two races do not seem to show any relation whatever between the grade of the house and the price per room per month. The remarkably low price paid by the negroes for the "100" grade houses has no significance, as it was based on a very small number of instances (only seven instances among the negroes of "100" grade houses in which information was obtained in regard to rent) in two of which the rent was exceeding small (seventy-five cents per month per room), thus lowering the average for that grade of house to a marked degree.

This chart would seem to indicate, if the Jews are excluded, that the grade of the house, which practically means its value from the standpoint of health, has absolutely no effect upon the rent. Granting that the variation in cost in the Jewish district does really represent the difference in healthfulness of the house, the difference between a very good house and a very bad house is found to amount to only about eighty cents a month per room. This suggests at least that the cry of "raising the cost of rent," which is heard whenever any plan is suggested for the bettering of the housing conditions, may be more theoretical than real, and even if real, may be not so great as to be a very serious drain upon the tenants. It is unfortunate that the information collected regarding this point was not more exhaustive and conclusive, as with this point definitely determined, many measures could be undertaken with the object of improving the character of the homes if it were shown they could be carried out without raising the cost to the tenant, or at least to any appreciable degree.

Cost of Stores.—In studying the rents paid for stores (in addition to a varying number of living rooms) in the above table, one notes that there is no constant relation between the number of rooms and the cost per month per room. This irregularity is probably due to the fact that the cost of the stores is influenced to a much greater degree than the living apartments by such factors as location, size of store, condition or equipment of store, good-will, etc. Upon these points the data collected were not sufficient to present a complete study of the rents paid.

Cost of Apartments in Homes of Owners.—The two special points brought out by a study of the cost of apartments in the homes of the owners are that the number of rooms leased are smaller (never more than five), and that the cost per room per month is distinctly higher than when rented from the landlord. This would make it appear that the people themselves, when they own property, demand higher rents than the average landlord. It is impossible to say whether these higher rents are due to the fact that these homes owned by the tenants are usually of a higher housing grade (as shown under Owners), and, therefore, can demand higher rents.

As the study of the living apartments would seem to indicate that the grade of the house had very little influence, if any, upon the rent, one would be more inclined to believe that these higher rents in the homes of the owners were either due to an effort on the part of the owners to insure their tenants being desirable, or else that they found financing the home too heavy a burden, which they were forced to relieve by charging high rentals.

It will be noted that the cost of the apartments rented from the owner follows the same general curve, according to the number of rooms to the apartment, that was found among the apartments rented from the landlords, being higher where only one room is rented and gradually falling as the number of rooms increases. The cost of stores was quite as irregular and indefinite when rented from the owners as when rented from the landlords.

As one would naturally expect, the cost of the apartments, when including a store, is distinctly higher than the living apartments without stores when rented from either landlord or owner.

PROPORTION OF INCOME EXPENDED IN RENT.

The amount of money that the people are required to pay out every month for rent gives one only a limited view of one side of the rent question.

Another point to consider, and one which probably has much more significance, is the proportion of the income which is spent upon rent. The following tables have been prepared showing the number and percentage of the families devoting different proportions of their income to rent.

TABLE 84.—PROPORTION OF INCOME EXPENDED FOR RENT IN JEWISH, ITALIAN, AND NEGRO DISTRICTS COMBINED.

PROPORTION OF INCOME EXPENDED FOR RENT	1-5 Per Cent.	6-10 Per Cent.	11-15 Per Cent.	16-20 Per Cent.	21-25 Per Cent.	26-30 Per Cent.	31-40 Per Cent.	41-50 Per Cent.	Over 50 Per Cent.	TOTAL
Number of families	87	135	222	115	65	26	38	12	13	713
Percentage of families	12.2	18.9	31.2	16.1	9.1	3.7	5.3	1.7	1.8	100.0
Combined percentages	62.3			25.2		12.5				100.0

When the families are divided according to the proportion of their income expended in rent, it will be noted that the largest group is the one spending between 11 and 15 per cent. of the income in rent. Combining them in larger groups, one finds that 62.3 per cent. spent only 15 per cent. or less of their income upon rent, and 87.5 per cent. devote one-fourth (25 per cent.) or less to rent. Probably the most striking point in the above table is the large proportion of the people (12.2 per cent.) who spent 5 per cent. or less upon rent. This will be referred to again in the following sections, where this question is considered according to race.

There is one point brought out by the above table which is very striking, and that is the very high proportion (38 per cent.) of negroes who expend less than 5 per cent. of their income upon rent, and the very small proportion of the Italians (0.8 per cent.). As it was found in the preceding table that the largest percentage of the total population spent between 11 and 15 per cent. of their income for rent, 15 per cent. will be taken as a standard for comparing the different races. The Jewish had 66.8 per cent. spending 15 per cent. or less, the Italians, 48.5 per cent., and the negroes, 72.5 per cent. In other words, the Italians devote the greatest proportion of their income to their home, the Jews come next, and the negroes spend relatively the least.

There are two factors which might have considerable bearing upon this question, namely, stores and lodgers, and the real situation in regard to this question of proportion of income spent upon rent cannot be determined until both are eliminated. Table 86 gives the exact conditions relative to stores and lodgers and their influence upon the proportion of income spent in rent.

TABLE 85.—PROPORTION OF INCOME EXPENDED FOR RENT BY EACH DISTRICT.

PROPORTION OF INCOME EXPENDED FOR RENT	1–5 Per Cent.	6–10 Per Cent.	11–15 Per Cent.	16–20 Per Cent.	21–25 Per Cent.	26–30 Per Cent.	31–40 Per Cent.	41–50 Per Cent.	Over 50 Per Cent.	TOTAL	NUMBER OF FAMILIES
Percentage of Jewish families	3.3	22.3	41.2	16.4	7.4	2.3	3.8	1.0	2.3	100.0	391
Percentage of Italian families	0.8	20.0	27.7	25.4	11.5	7.0	3.8	2.3	1.5	100.0	130
Percentage of negro families	38.0	11.5	13.0	9.4	10.9	4.2	9.4	2.6	1.0	100.0	192

TABLE 86.—RELATION OF STORES AND LODGERS TO THE PROPORTION OF INCOME EXPENDED FOR RENT.

PROPORTION OF INCOME EXPENDED FOR RENT	1–5 Per Cent.	6–10 Per Cent.	11–15 Per Cent.	16–20 Per Cent.	21–25 Per Cent.	26–30 Per Cent.	31–40 Per Cent.	41–50 Per Cent.	Over 50 Per Cent.	TOTAL	NUMBER OF FAMILIES	
TOTAL:												
No stores and no lodgers	15.0	19.2	31.0	17.9	9.8	3.1	2.9	0.2	0.9	100.0	520	713
No lodgers, having *stores*	0	8.3	20.8	0	16.7	4.2	12.5	16.7	20.8	100.0	24	
No stores, having *lodgers*	5.3	19.5	33.2	13.0	5.9	5.3	11.8	4.2	1.8	100.0	169	
JEWISH:												
No stores and no lodgers	4.0	23.0	40.1	18.6	8.0	1.6	3.3	0	1.3	100.0	300	391
No lodgers, having *stores*	0	12.5	18.75	0	12.5	0	12.5	18.75	25.0	100.0	16	
No stores, having *lodgers*	1.3	21.4	49.4	12.0	4.0	5.3	4.0	1.3	1.3	100.0	75	
ITALIAN:												
No stores and no lodgers	1.1	18.3	27.9	30.1	12.9	7.5	1.1	0	1.1	100.0	93	130
No lodgers, having *stores*	0	0	25.0	0	25.0	12.5	12.5	12.5	12.5	100.0	8	
No stores, having *lodgers*	0	31.0	27.6	17.2	3.5	3.5	10.3	6.9	0	100.0	29	
NEGRO:												
No stores and no lodgers	51.2	11.0	11.0	7.8	11.8	3.2	3.2	0.8	0	100.0	127	192
No lodgers, having *stores*	..	..	..	..	..	..	..	..	..	..	..	
No stores, having *lodgers*	12.3	12.3	16.9	12.3	9.2	6.2	21.5	6.2	3.1	100.0	65	

The elimination of stores and lodgers only makes more striking the large proportion of negroes (51.2 per cent.) spending 5 per cent. of their income or less on rent. Taking, as before, 15 per cent. of income as a standard, and eliminating stores and lodgers, one finds the Jews have 67.1 per cent., the Italians, 47.3 per cent., and the negroes, 73.2 per cent., spending 15 per cent. or less of their income in rent.

What the apparent effect of stores upon this problem is may be readily seen by comparing the first and second rows of figures in each subdivision. The Jews with stores have 31.25 per cent., spending 15 per cent. or less of income upon rent, instead of 67.1 per cent.; the Italians, 25 per cent. instead of 47.3 per cent. The negroes did not have sufficient stores (only two) to have any significance. Those having stores, therefore, spend a much greater proportion of their income for rent, which is what one would naturally expect.

The effect of lodgers may be seen by comparing the first and last rows of percentages under each nationality. The Jews, if lodgers are included, have 58 per cent. spending 15 per cent. or less of their income upon rent, instead of 67.1 per cent.; the Italians with lodgers have 58.6 per cent. instead of 47.3 per cent., and the negroes have 40.5 per cent. instead of 73.2 per cent. The relative cost of the apartments among the Jews and negroes is raised by the presence of lodgers, while it is lowered among the Italians. This would indicate that whereas the lodgers among the Italians pay a relatively small proportion of their income for lodging, it is probably due to the fact that many lodgers share a room together (see section on Crowding). Among the negroes, on the other hand, the relative rent is increased by the presence of lodgers, while the crowding is diminished, indicating that the negroes' lodgers probably have a room to themselves, which would explain both conditions.

A possible explanation for the situation among the Jews, where crowding was increased by the lodgers, even to a greater degree than among the Italians, and the relative cost of rent was also increased, is that while many may have occupied one room, they paid a relatively higher price for the same than the Italians.

These explanations are not borne out by a study of the amounts paid by the different races for one "room," except in the case of the negroes. It will be seen that the negroes paid only about $3.10 per month for a single room, while the Jews and Italians paid $4.75 and $5.25 respectively. The real explanation would, therefore, seem to lie in the fact that the Jewish were paid much smaller wages.

From a study of all the districts combined ("Total") one would say that the renting of stores demands a much greater proportion of income devoted to rent, and that the lodgers tend also slightly to increase the proportion of income expended upon rent—the exception to this being found among the Italians, where the lodgers tend to cut down the proportion of income expended upon rent.

There were two instances found in which the rent exceeded the income, although there was no information recorded to explain whether their landlord permitted them to go into debt, whether they were assisted by charity, or whether it was simply a temporary condition due to illness or loss of position by one or more of the wage-earners in the family.

NATIONALITY.

There are several points brought out in the foregoing pages which seem to point to certain racial characteristics that are worthy of special mention. As the conclusions are based upon small groups of each race, in making comparisons between the different races it must be clearly understood that the remarks refer only to the districts examined, and must not be taken to represent the race as a whole. The groups are large enough, however, to render the findings very suggestive. By far the most striking feature of the entire investigation from the standpoint of race was the remarkable degree of cleanliness in the homes of the negroes. In view of the existing conditions the cleanliness among the Italians must also be considered high. Another point of interest is shown by the number of Italians owning their own homes, and the very few among the negroes. This exemplifies very well the thrift of the one group and the improvidence of the other. The question of income can hardly affect this comparison. This confirms the need for the establishment of more work along the lines of the Thrift Clubs of the Whittier Center and similar organizations who are working among the negroes.

The difference in the conditions among the different races is well shown in regard to the "lodger evil." Among the negroes, for example, as far as overcrowding is concerned, it appears to be a favorable feature, while among the Italians it is a very great evil. The speaking of a foreign tongue and the presence of a distinct "race sympathy" are probably largely responsible for this condition among the Italians. Thrift may be also partly to blame, as where these people buy a house they depend frequently upon lodgers to increase their income in order to carry the financial burden of the house.

It is nearly time that the American cities began to appreciate their responsibilities in regard to these foreign races, which come in such large numbers to this country. There is certainly not sufficient provision made to see that they are properly distributed throughout the country and prevented from swarming into the large cities, although the Emigration Bureau of New York State is doing excellent work. If they are allowed to concentrate in the cities, it is clearly evident that the houses provided for their accommodation should be suitable, at least, from the standpoint of health. This is made very evident by the study of the period at which they develop tuberculosis after coming to this country. (See article on Housing, page 13.)

THE CONCLUSIONS that have seemed justified by the findings in regard to special features covered by the investigation have been included in the section relating to that subject. It is impossible, however, to make a study similar to the foregoing without being impressed by several fundamental facts, the most striking of which is the very inadequate measures adopted to protect the people against disease. The analogy between crime and disease is very close and the means adopted for the prevention of one could be equally well applied to the other. There is one large portion of the population that education alone is sufficient to prevent from performing acts prejudicial to the public welfare; the remainder are only prevented from such acts by police supervision. The problem of the health of the public will never be solved until a vigorous, wide-spread campaign of education has reached the first, and sanitary police, or inspectors with police powers, are provided for the second group.

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APARTMENT CARD

STREET.......................................NO..............................DATE..INVESTIGATOR ....

FAMILY

HEAD OF HOUSEHOLD..NATIVITY..

	LIVING	DEAD	DATE	AGE	OCCUP.	WHERE	EARNINGS
F							
M							
S							
D							
S							
D							

Entire House
Apartment
Floor
No. Rooms
Front
Rear
Rent wk.
mo.
No. in family
Lodgers
male
female
Pay

Total
Total Income

Rent

	WATER CLOSETS	BATHS	BASINS	WASH TUBS	SINKS	FIRE ESCAPES	BACK STAIRS
Number						St. Al. Yd. Ct. Wood Iron Encumbered Sound Safe C F D Needed	Inside Outside Open Inclosed Wood Iron Stone Encumbered C D F Safe G F B Straight Winding Railing Steep Access to Light L G D
Location							
Cleanliness C D F							
Repair							
Inclosed							
Trapped							
Vented							
Sat'd wood work							

ROOMS								BEDS			
No.	Use	Windows	Outlook	Light	Ventilation	Cleanliness	Repair	No.	No. in Bed	Size	Dist. Ap't
1											
2											
3											
4											
5											
6											
7											
8											

WATER SUPPLY
Separate
Hydrant
Well
Where
Condition
Adequate

WATER CLOSET ACCOM.
Separate
Where
Suitable
Defective Fixtures

VENTILATION
Outer Air
Vent shaft
Adj'g rm.
Adeq.
None

General Condition and Aspect

Moral Conditions and Influences

Any Special Dangers or Conditions Not Covered

General Remarks or Recommendations

*

Photograph Recommended to Show

Abbreviations.—LH., SH., Wo., OW., SJ., TW., Wd.,—Long Hopper, Short Hopper, Washout, Offset Washout, Siphon Jet, Tidal Wave, Washdown; C D F—Clean, Dirty, Filthy; G F B—Good, Fair, Bad; L G D—Light, Gloomy, Dark; F S R—Front, Side Rear; Y—Yes; O—No.

DIAGRAM OF APARTMENT

Front—N E. S. W.

Scale........Ft. to the square.

THE HENRY PHIPPS INSTITUTE—UNIVERSITY OF PENNSYLVANIA

BUILDING CARD

STREET...NO...DATE...INVESTIGATOR ....

ENVIRONMENT	YARD	YARD TOILETS	BUILDINGS	CELLAR BASEMENT	PLUMBING LINES	HALLS AND STAIRS
STREET Width Clean C D F ALLEY Width Property Al. Block Al. HOUSE FACES Street Alley Back Yard LOT Corner Through % Covered ANIMALS Kind Number Where NUISANCE Smoke Odors Noise Source	YARD Front Back Side Size Paved Earth Grass Garden RUBBISH F S M Clean C D F FENCES DRAINAGE Sewer Surface Adequate DAMPNESS Dry Damp Water HYDRANT Location Condition Supply A D N Families Using WELL Pump Covered DRAIN Clean C D F Free Obstructed CESSPOOL Location Condition RECEPTACLES Material Suitable Adequate Nuisance Garbage Ash	PRIVY Size No. Comp't No. Fam'l us'g Repairs G F B Clean C D F Sewer Connected Flush Offset Foul WATER CLOSET Size No. Com't No. Fam'l us'g Repairs G F B Clean C D F Sat'd Woodwork STABLE Size Occupied How near house Manure Pile (cov'd)	HOUSE Size Material Location F S R No. Stories Attic Base. Cellar REPAIRS G F B USE OF HOUSE Store Shop Where Kind FIRE ESCAPE NEAREST BLDGS. Distance Windows Facing N S E W OTHER BLDGS.	ACCESS FROM Street Yard Interior SIZE % of house Entire house USE Ordinary Storage Business Living Sleeping FLOOR Earth Wood Brick Cement WALLS Material W W or P C D F CEILING Ft. from floor Ft. from ground Space outside Material W W or P C D F	RAIN LEADERS Location Repair G F B Used as waste pipe Discharge where Eaves pipe WASTE Openings Vent Where to Bandaged SOIL HOUSE DRAIN Exposed cov'd Material iron Free obstructed Patched sound Openings noted Test cap DAMPNESS Dry Damp Water Under what weather VENTILATION Sufficient? LIGHT L G D CLEAN C D F REPAIR G F B	Enter from How lighted Where end Steep Straight Spiral Landings Railings Cleanliness C D F Repair G F B Width FIXTURES Sink Toilet Apartments using ROOF REPAIR Tight Leaking Rubbish F S M

Dangerous Conditions

Remarks

Photograph Recommended to Show

Owner.. **Agent**.........................

Address...

Abbreviations—G F B—Good, Fair, Bad; C D F—Clean, Dirty, Filthy; A D N—Adequate, Deficient, None; F S M—Free, Some, Much; L G D—Light, Gloomy, Dark; F S R—Front, Side, Rear; W W or P—Whitewash or Paint; LH, SH, Wo, OW, SJ, TW, Wd—Long Hopper, Short Hopper, Washout, Offset Washout, Siphon Jet, Tidal Wave, Wash down. Y—Yes; O—No.

DIAGRAM OF PREMISES—HOUSE.

Front—N. E. S. W.

Indicates fences, walls, buildings, etc., on lot boundaries.

UNIVERSITY OF PENNSYLVANIA

TWELFTH REPORT

OF THE

HENRY PHIPPS INSTITUTE

FOR THE STUDY, TREATMENT, AND PREVENTION OF TUBERCULOSIS

STORAGE, HANDLING, AND SALE OF FOOD IN PHILADELPHIA

JANICE S. REED LIT
RESEARCH ASSISTANT IN SOCIOLOGY

FOOD INSPECTION SERVICE IN PHILADELPHIA

BUREAU OF MUNICIPAL RESEARCH OF PHILADELPHIA

PUBLISHED BY THE
HENRY PHIPPS INSTITUTE
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1916

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INTRODUCTION

The data contained in this report is the result of a study made about a year ago. The investigation was not undertaken in a spirit of faultfinding, and especial pains were taken to obtain an average picture of conditions rather than to emphasize all that was bad. The neglect of the food problem is not willful: it is simply one of the faults of the times in which we live. The first step towards obtaining better conditions lies in calling attention to existing defects and in disseminating the knowledge as to how these defects are detrimental to the public health. It is necessarily "one of the evolutionary steps in the journey from no knowledge at all of how to proceed to a program based upon exact knowledge of how to do things." It is hoped that this small contribution will serve to pave the way to obtaining the consideration the subject demands.

The protection of food is a matter which directly concerns departments of health. The conditions under which various articles of food are produced; the manner in which they are cared for before passing into the hands of the consumer; and the health of the individual engaged in handling them, are of the utmost importance in the prevention of disease. Given the proper equipment and authority, all diseases which can be traced to food may be reduced to a minimum.

The following brief summary will serve to show some of the ways in which food acts as a disease producer:

Foodstuffs may act as the medium by which disease is acquired in several ways: (1) The food itself may undergo changes which render it dangerous; (2) the food may be diseased, as in the case of meats; (3) the food may be rendered dangerous by accidental contamination from outside sources.

(1) *Changes in the Food.*—For the most part this applies to meats, fish, and shellfish. The most common change is that due to putrefaction, usually the result of poor storage methods. As a rule, meat which has undergone putrefactive changes shows alterations of appearance, of smell, or of taste.

Severe symptoms of poisoning may occur also from eating meat from cattle which have had some septic or diarrheal condition. The important point in connection with this type of poisoning is that the meat presents a normal appearance. The various products of milk, such as cheese, ice cream, and custard, may give rise to severe gastro-intestinal symptoms if the milk from which these products have been made has undergone putrefactive changes.

Fungus disease of grain occasionally is met with. The use of meals made from grains contaminated with the ergot fungus often gives rise to very serious nervous symptoms. Epidemics of ergotism are not uncommon in certain parts of Europe. Within the past few years two diseases, namely, pellagra and beri-beri, have been subject to a great deal of study. Both are believed to be due to food poisoning. At one time the belief that pellagra was caused by eating spoiled corn was generally accepted; and although some doubt has been thrown on this hypothesis there can be no question as to the importance of careful inspection to prevent the use of spoiled corn, particularly in institutions. While the cause of beri-beri has not been absolutely traced, there is every reason to believe that it is in some way connected with the eating of polished rice. In the process of "polishing" or "milling" the pericarp is removed from the rice grain and it is the absence of this substance which is believed to bring about the disease.

(2) *Diseased Food.*—The best-known example of this is trichiniasis. This disease is due to a parasite, the *trichina spiralis*, which infests hogs. The eating of raw ham or insufficiently cooked pork often leads to the infection of human beings. Protection against this source of danger lies in the proper inspection of the slaughtered carcasses, and—even more important—the thorough cooking of the flesh so that all parts of the meat reach the boiling point. While the danger from the flesh of tuberculous cattle or hogs may be slight such animals should be rejected for food purposes.

(3) *Contamination of Food.*—This is perhaps the most important phase of the food problem. In some instances we have a very complete knowledge of how the contamination occurs. In the case of milk, for instance, there is ample proof to show that this article of diet may be the sole clue by which we can explain epidemics of typhoid fever, diphtheria, scarlet fever, and septic sore throat and gastro-enteritis. Furthermore, it has been demonstrated, beyond any question of doubt, that the milk of tuberculous cows is the source of a not inconsiderable number of cases of tuberculosis in infants and young children. Milk may become contaminated in a variety of ways. It may be due to disease of the animal from which it is obtained; it may be due to dirty methods of handling it; or it may be due to disease of the milker or one of his family. There are now on record many epidemics in which the source of trouble could be traced to a case of typhoid fever, scarlet fever, etc., among the employees of the dairy.

Another well-known example of food contamination is the fattening of oysters in fresh water which has been polluted with sewage. Many epidemics of typhoid fever have been traced to this source.

As to the contamination of other articles of food, our knowledge is not so complete, but it is not difficult to believe that the careless manner in which practically all foodstuffs, and especially those which are eaten raw, are exposed to promiscuous handling by prospective buyers, to street dust, and to flies, must constitute a considerable source of danger.

Within the past few years a very important source of food contamination has been discovered in the so-called "carriers." At the present time the best-known example of this source of danger is the "typhoid carrier." It is now recognized that a certain percentage of individuals who recover from typhoid fever continue to harbor virulent typhoid bacilli which they excrete in the feces. Such individuals, if filthy in their habits, may contaminate food. The case of the notorious "Typhoid Mary" of New York City is well known. At the present time the health authorities of New York City have under their surveillance some fifteen or more of these carriers.

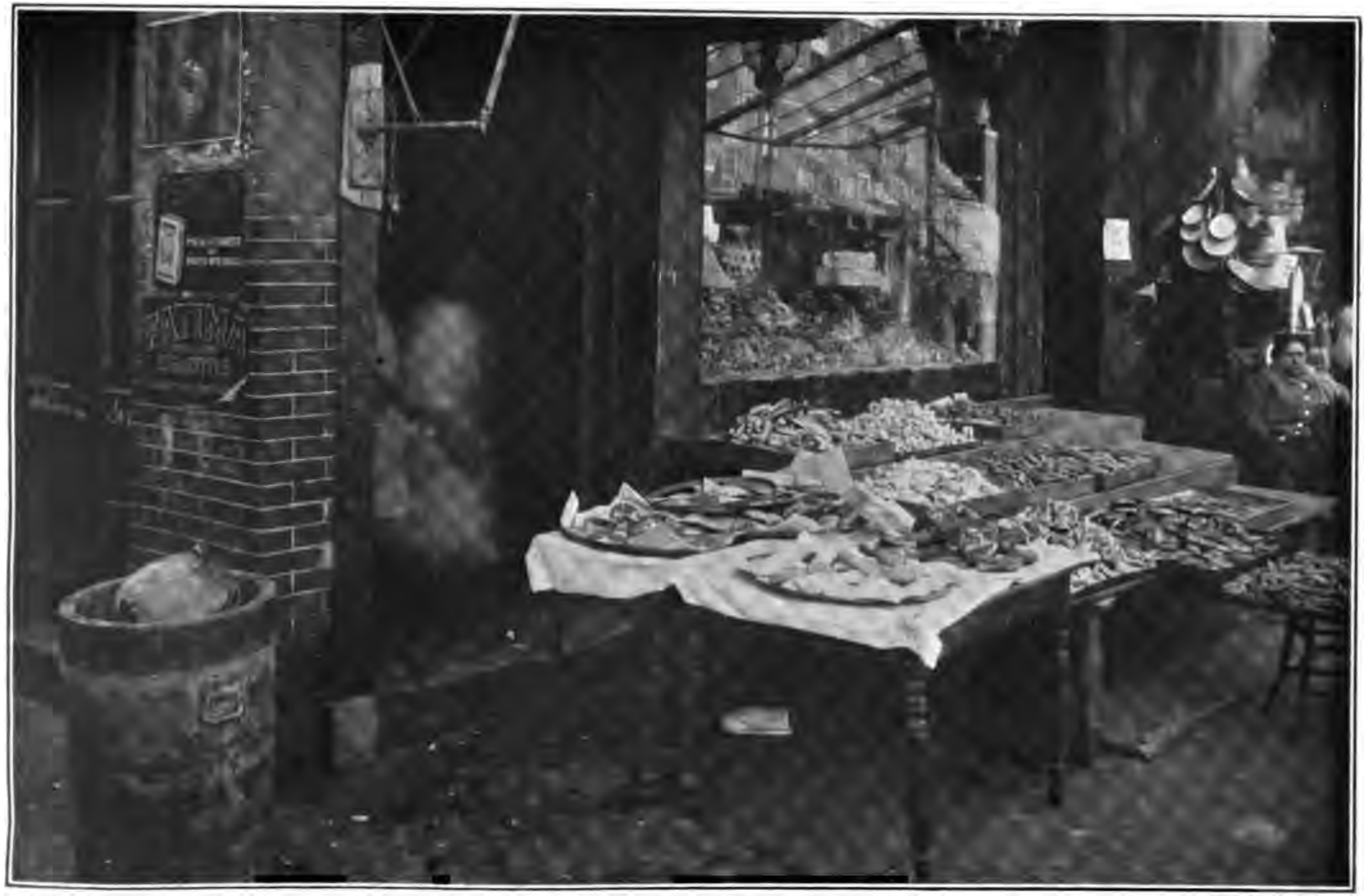
Recognizing the ever-present danger of disease being transmitted by a "carrier" the Board of Health of Manila, P. I., requires that every individual engaged in the handling of foodstuffs (in markets, restaurants, at soda-water fountains, etc.) shall be examined and shall be shown to be free from tuberculosis, chronic typhoid or cholera, or other transmissible disease.

This brief and imperfect outline of the diseases which may be caused by food, and the manner in which these diseases are produced, serves to emphasize the importance of the problem. Furthermore, in every instance there is an efficient method of prevention. The neglect of these precautions simply means that an unusually large amount of illness and a considerable number of deaths occur for which there is no excuse.

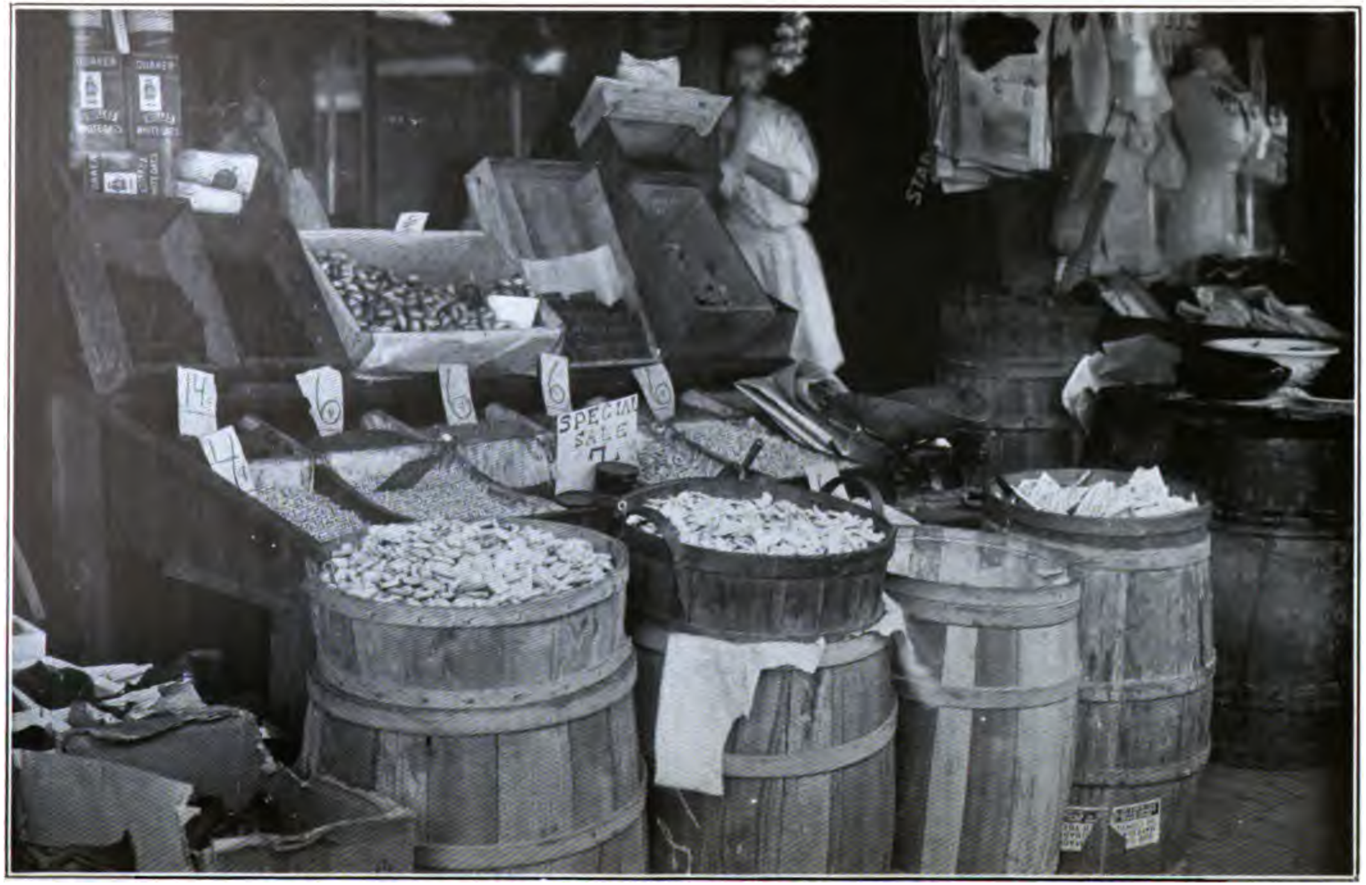
For the efficient supervision of perishable foods the following requirements are necessary: (1) An adequate force of inspectors. The men or women so employed should have a proper conception of their duties. In the case of milk and meat inspection an expert veterinarian with a comprehensive knowledge of every angle of the milk and meat industry is essential to success. (2) Every municipality should have as exact knowledge as possible of the sources from which its food is obtained. This applies principally to milk, but should, so far as is possible, include oysters. Inasmuch as certain definite localities are concerned in the production of oysters, Federal control is the only remedy. (3) Federal control of the meat industry is also essential, as most large communities are dependent to a great extent on meat shipped from distant points. In order to do away with small privately owned slaughter-houses, which are supervised with difficulty, every municipality should establish its own abattoir. In this way the meat can be efficiently inspected and at a minimum of expense. (4) All persons engaged in the handling of foodstuffs in public places should be examined in order to determine whether they are suffering from any communicable disease. (5) The budget of the Department of Health must be made adequate to the needs of the community. It is worth mentioning at this point that the neglect of the perishable food problem in Philadelphia is to a great extent, if not entirely, due to lack of money. Of six of the leading cities in the country, Philadelphia stands last, with an expenditure of $.0166 per capita as compared to Pittsburgh, with $.0999 per capita. As a result Philadelphia has the fewest and the most poorly paid inspectors in this group of cities. As the Bureau of Municipal Research has pointed out, if Philadelphia were to pay five cents ($0.05) per capita for food inspection, less than the average of these other cities, the total appropriation would be $82,500 as compared with the present $27,352. (6) Finally, for the solution of this problem, as in all other matters relating to public health administration, municipalities must see to it that their health department is freed from the curse of "political expediency." One of the reasons why the public health administrations of our American cities are so backward may be traced to the fact that they are, to a greater or less extent, under the domination of politics. Public-health work is a highly specialized branch of medicine and one that requires special training. If a health department is to become efficient it must not be subject either to political domination or to the frequent changes in the personnel of the city government.

At the present time the epidemic of acute poliomyelitis or infantile paralysis emphasizes very forcibly how dangerous an acute infectious disease may become. Especially is this the case when we lack the knowledge of how the infection is transmitted from one individual to another. It is quite within the bounds of possibility that infantile paralysis may be associated, in some way, with contaminated food. Lacking the absolute proof that it is not, should be an incentive to eliminate this source of danger.

H. R. M. LANDIS.



Photograph No. 1.—Showing street exposure of cakes and pastries in hot summer months. No protection against flies or dust.



Photograph No. 2.—Street exposure of crackers, fruits, and cereals. Newspapers hanging up are used for wrapping.

STORAGE, HANDLING, AND SALE OF FOOD IN PHILADELPHIA

JANICE S. REED LIT
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Need for Investigation.—The causes of ill health, the prevalence of disease, and the comparatively high death rate in Philadelphia must, of course, be many. Prominent among them is the food question. No one doubts that the way in which food is handled and stored before it reaches us has an intimate relation to our physical well-being. If we knew and realized the conditions under which food is stored, the way and by whom it is handled, and how much dust and dirt it has accumulated during its exposure in the stores and markets before it is purchased, we would, if merely from a sense of decency, be more insistent upon better protection and inspection of our foodstuffs. Philadelphia now has numerous laws and ordinances regulating the sale of certain foods. It also has a municipal division of Food Inspection for enforcing these regulations.

Much can be accomplished directly through the education of consumers. The shopkeeper must meet the demands of his customers. If they want the food that they buy covered and protected from the dust and dirt, they have merely to tell their dealer this, and if he finds that he must comply with these requests to keep their trade, it can be depended upon that he will do it. This is plainly illustrated by the contrast between stores in the residential and in the congested sections of the city. But even in the better districts, where there is a demand for more careful handling of foods, there is still room for improvement. Even in many of the best stores in the city there are numerous instances of the exposure to dust and flies of foods eaten without further preparation, washing, or cooking. In many cases vegetables and fruits are not raised eighteen inches, or even a foot, above the floor.

In addition to the lack of screening and covering of foods inside the stores the wholesale street exposure, especially in the southern section of the city, demands attention. (Photograph No. 1.) Here raisins, currants, crackers, rice, beans, and many other dry groceries, as well as fruits, vegetables, and breadstuffs, are displayed along the sidewalk outside of the shops. (Photograph No. 2.) Meat also is often similarly exposed and, worse still, offered for sale side by side with live poultry. People wearing filthy clothes and with grimy hands serve the public in these shops, and as a rule wrap up their commodities in newspaper—a practice which is prohibited by the Bureau of Health. Naturally flies flourish in such places. (Photograph No. 3.) It needs only to be mentioned, to complete the picture, that when the street-sweepers pass they raise a cloud of dust to settle on the food.

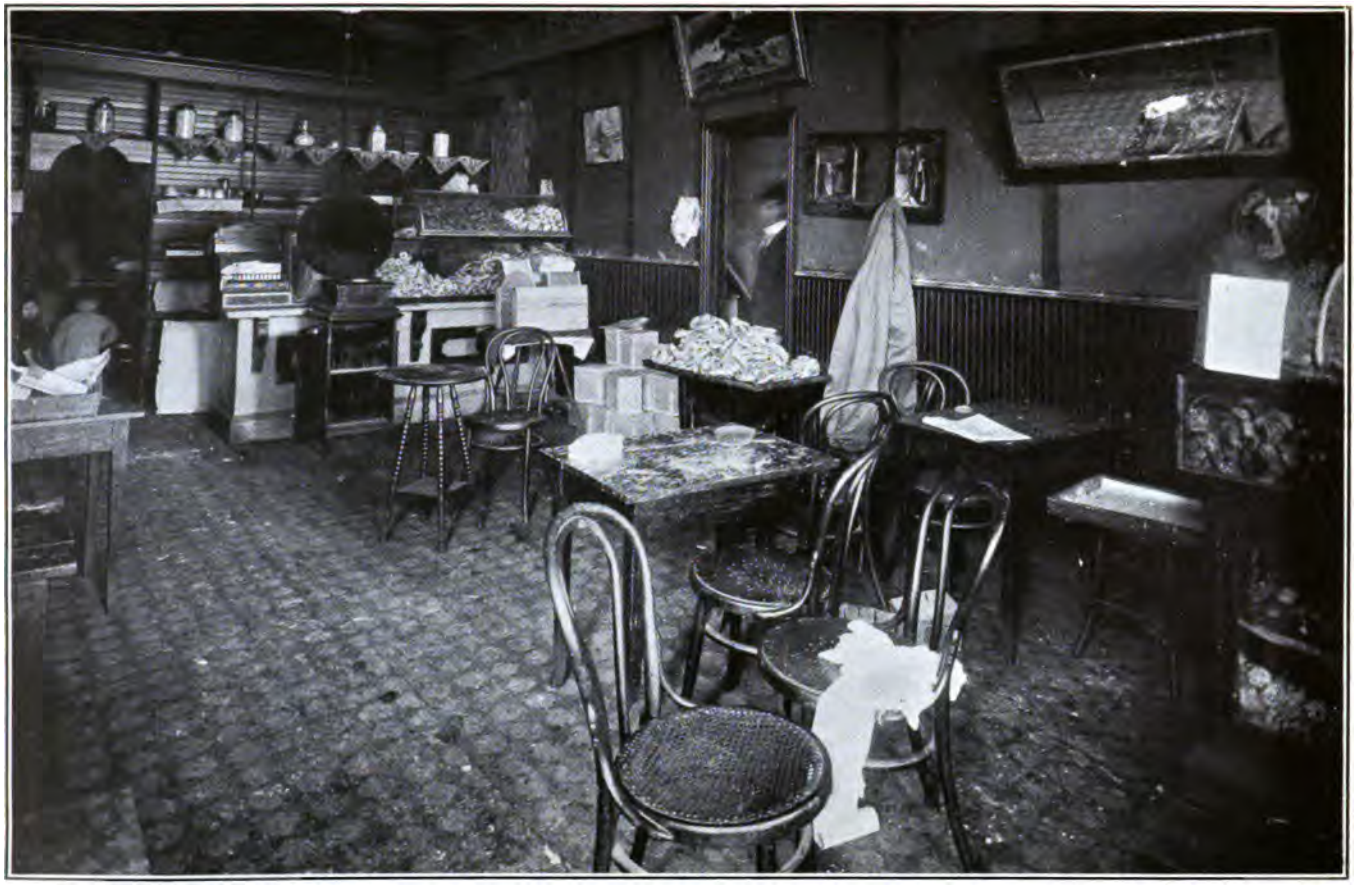
The need for regulation and inspection is widespread and urgent. The city has control over only a limited number of products—meat and meat-food products, cattle, fish, milk and its fluid derivatives. The small force provided for this purpose—fourteen milk and seven meat inspectors with their two chiefs—can cope but very inadequately with even that restricted portion of our food supply.

Field Covered.—The Sociological Department of the Henry Phipps Institute, in 1915, under the direction of Mrs. Janice S. Reed Lit, made an investigation in Philadelphia of over 1,000 stores and about 200 push-carts and street stands. Being without laboratory facilities, the exact condition of foods with reference to bacteria could not be determined, but stores and carts were examined and scored for various determining elements—sanitation, type and number of workers, protection of food against contamination, grade of food handled, storage of food in the homes of the vendors, etc. A tabulation of these scores discloses startling and disgraceful conditions.

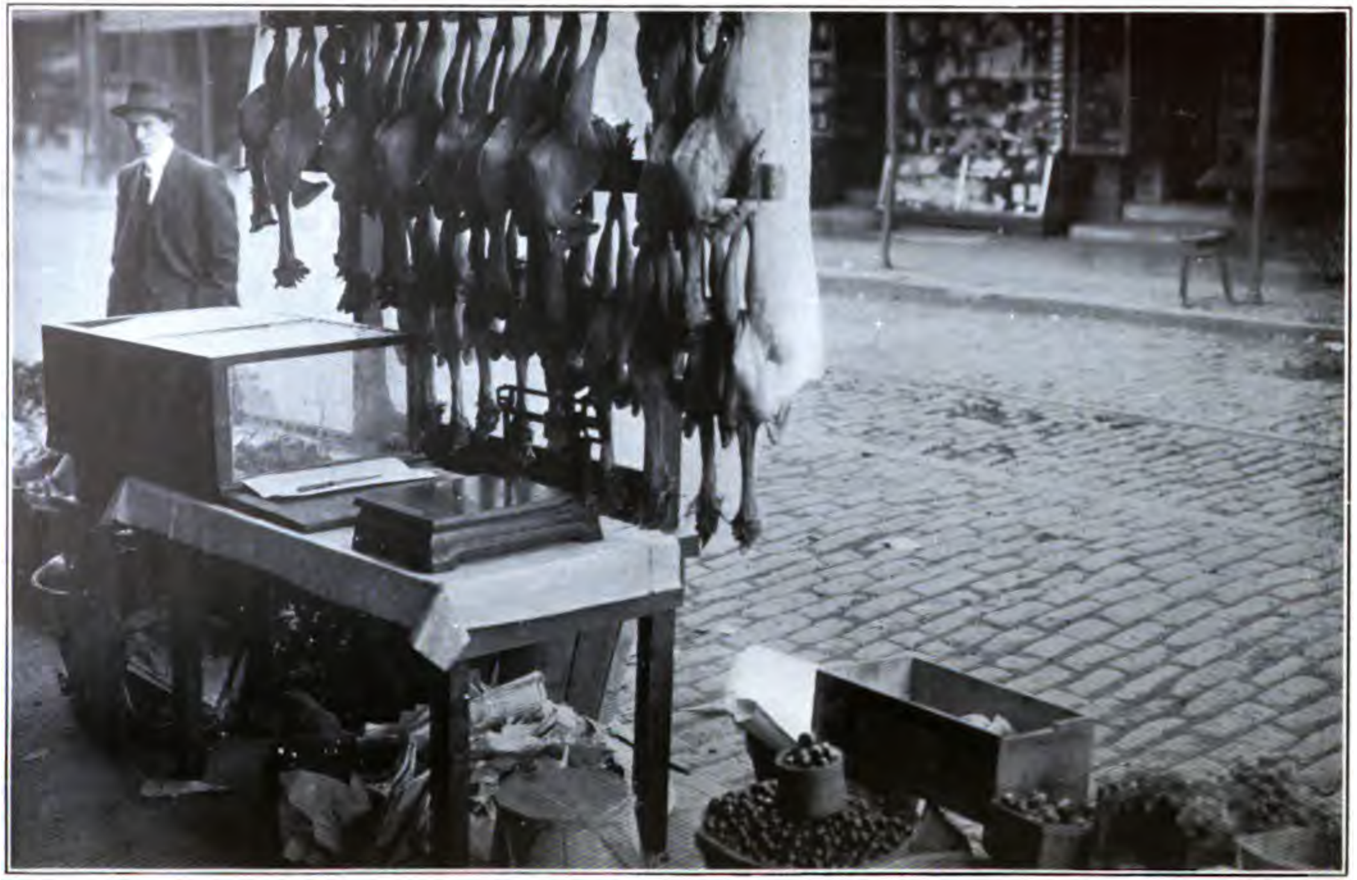
Selection of Districts.—The districts chosen for study are considered as representative of various sections of the city. Race or nationality, degree of congestion, and previous health investigations played a considerable part in their selection. Jewish, colored, American, Italian, German, Polish, Irish, and mixed settlements were studied; congested and residential sections; and an effort was made to include in the study those portions of the city covered in the report of the Child Federation on infant mortality, Phipps Institute's study on tuberculosis, standards of living and housing, and the Housing Commission's report on congestion, in the hope that the data on food might throw some additional light on these other problems.

Variety of Shops.—All kinds of shops were studied, groceries, bakeries, meat shops, fish markets, creameries, ice-cream and confectionery stores, and produce establishments. (Photograph No. 4.) A district at least a block in extent was selected in each case and every store in that block investigated and scored.

Method of Inspection, Scoring, and Tabulation.—On the field cards, Exhibit 1 for stores and 2 for push-carts, provision was made for noting all sanitary and social conditions which would in any way affect the method of storage, display, handling, and sale of foods: type of building and room, drainage, sanitation, surroundings, water supply, etc., as well as the nationality of the proprietor, the time he has spent in the United States, his personal appearance and that of the workers.



Photograph No. 4.—Interior exposure to contamination in an "Ice-cream Parlor" infested with flies. Cakes uncovered.



Photograph No. 3.—Street exposure of poultry in violation of city ordinances. Newspapers under table used for wrapping purposes.

The variety of conditions which were found in the stores and shops examined preliminary to the selection of the districts and the preparation of the final field card made it evident that a more refined method of scoring than the usual designation of good, fair, bad, and very bad was necessary. As a result of this observation, a scoring system ranging from 1 to 100 was provided for in the case of some of the elements studied, while in others, 1 to 4, designating good, fair, bad, and very bad was adopted. In addition to the numerical scorings, a limited amount of descriptive material was also provided for on the cards.

In calculating the various scores certain factors, such as degree of perishability had to be taken into account. Different weights, therefore, were given to different foods—non-perishable foods and those not easily contaminated were given a weight of 1, confectionery, 2, and all perishable foods and those easily contaminated, 3. In calculating the general food score, therefore, the separate scores given to these foods must be multiplied by 1, 2, or 3 respectively, the results added, and the total divided by the total number of factors. To this final score 25 was added to offset the difficulty of reversing scores by subtracting from 100. The weights for storage and street display were 3 and 4 respectively; those for wash-rooms and toilets, 1 and 2; and those for refrigerator, cellar or basement, main work-room and front shop, 1, 1, 3, and 3 respectively. An additional 25 was added to the score for the type of room, also. In computing the air space the following table was used:

If less than 200 cu. ft. per person, score 4
If between 200 and 250 cu. ft. per person, score 3
If between 250 and 350 cu. ft. per person, score 2
If over 350 cu. ft. per person, score 1

After the scores for the various sections of the card were computed by multiplying the scores given by the respective weights, adding, and dividing the sum by the total number of weight units, the general score for the store was derived. Here again weights figured, 1 for the average scores for toilet facilities, surroundings, and type of workers, 2 for the score for foodstuffs, and 4 for the score for type of room. The divisor here should be 9, therefore, but if there was street display 11 was used. For example:

Average score for type of room	60 x 4 =	240
Average score for foodstuffs	35 x 2 =	70
Average score for toilet facilities	55 x 1 =	55
Average score for surroundings	65 x 1 =	65
Average score for type of workers	50 x 1 =	50
Total		480

No street display... 9)480(53.3
Street display...... 11)480(43.6

The score for this store therefore would be 43.6 if it displayed its goods along the street, or 53.3 if it did not.

After the investigations were made and the scores computed the information was tabulated, Exhibits 3 to 19, so that deductions could be made.

While many of the stores carried a great variety of food products, practically all of them specialized along some particular line so that they could be classified into groups of stores according to the business conducted. Some of the tables were made upon the basis of this classification, while others were based upon the classification of food sold in each place. In the latter case the same store may appear on the table under "vegetables," "fruit," "groceries," etc.

Interpretation of Tables Compiled on Store Investigations.—The types of stores which came within the scope of the present investigation as shown on Exhibit 3 are as follows:

	NUMBER	PER CENT.
Grocery	398	38.6
Bakery	112	10.9
Meat	182	17.7
Fish	30	2.9
Creamery	64	6.2
Ice cream	13	1.3
Provision	100	9.7
Confectionery	96	9.3
Restaurant	35	3.4
	1030	100.0

The first thing to be noted is that of these 1030 stores 920, or 89.3 per cent., have a general shop score of 7 or over. This means that a large majority of the stores were, all things considered, in fairly good condition. But this figure must be immediately compared with the results shown on Exhibit 4, the score based upon the actual conditions of the food—protection against dust, handling, and flies, upon the condition of preservation, storage, and street display.

Here only 56.9 per cent. of the foods score 7 or over. Thus it appears at once that while the building may be in fair condition in nearly 90 per cent. of the cases, yet almost half of them handled their commodities carelessly. Almost 6 per cent. (5.9) of them, moreover, scored only 10 or less on the basis of 100. That stores should be allowed to remain open where food is handled so wretchedly as to merit a score so low is a disgrace to the city and a menace to the population.

Let us analyze farther. Exhibit 5 gives the kinds of business according to the general score. It shows the percentages of the different kinds of stores which have a general score of 3, 4, 5, 6, etc., and shows which classes of food receive the best care and inspection, as well as the number of all stores receiving the various ratings. For instance, 22.3 per cent. of the grocery stores and 22 per cent. of the meat stores have a score of 9, while only 7 per cent. of the provision stores studied have such a score. Provision stores make a poor showing on this table, 66 per cent. of them having a score of less than 7. The confectionery stores have the best score, 90.6 per cent. being 7 or over.

The store and its commodities are pretty apt to reflect in a measure the conditions surrounding them. With this in mind the outbuildings, streets, yards, garbage and waste accumulation and removal for each store were scored. Generally speaking, in these matters the conditions are fairly good. The almost constant score for surroundings, Exhibit 6, is 7, 34.2 per cent. receiving this rating while 80.7 per cent. of the total number score at least this or more. It is worthy of note that in this respect milk, one of the commodities under municipal inspection, makes a very good showing—21.2 per cent. standing at 7 and 56.2 per cent. at 8 or over.

The sanitary provisions of a store, the water supply, cleanliness, condition of repair, etc., of the toilets and wash-rooms very largely condition the care with which our food is handled. That in over 50 per cent. (50.4) of the cases of food handling the sanitation score was less than 7, Exhibit 7, affords material for thought. Add to this the fact that many foods are eaten without further preparation, and we are confronted with a grave situation. The percentages of scores less than 7 for such foods are 59 for fruit, 43 for pastry, 46 for bread, 48 for confectionery, 50 for butter and cheese, and 48 for milk.

Exhibits 8, 9, and 10 give the sanitary score again, but this time in connection with the workers in the stores. Exhibit 10 is a recapitulation of 8 and 9, which give the number of male and female workers in detail with their scores. Of the 1721 groups of workers 845, or 49 per cent., work where the score for sanitation is less than 7, and of these 845, 52 per cent. are men and 48 per cent. women.

In dealing with the larger shops, those employing 10 or more workers, 75.9 per cent. have a sanitary score of 7 or over. This shows that the small dealer, therefore, is responsible for the generally low score. Of the stores, 691 employ both men and women, while the remainder, 339, have only male or only female workers.

An examination of the workers themselves, their health, cleanliness, and clothing, gives the scores shown in Exhibit 11. This is perhaps the most promising table of the lot, with only 17 per cent. under 7. Of these, the dealers in poultry, fish, and dried fruit are the worst, although in even these instances more than 70 per cent. of the entire number of dealers handling such commodities have a score of 7 or over. The dealers in pastry are perhaps the best so far as this score goes, only 8.6 per cent. of them being less than 7 and 50 per cent. scoring 10. Confectionery and milk dealers also rank high, 51.6 per cent. and 53 per cent. respectively scoring 10, and 12.4 per cent. and 13.5 per cent. scoring less than 7.

Surface drainage, of course, makes difficult the proper protection of food, especially if the food is exposed outside of the store. This factor was not secured in 48.4 per cent. of the cases, Exhibit 12, but of the remaining instances, 14.1 per cent. were found not to be underdrained.

Many foods are handled, also, in places where there is but an insufficient supply of water, 21.6 per cent. in all. In such places the workers very often are forced to go without washing their hands for hours at a time, and during this period they may be directly handling the foods, unpacking canned goods, rolling barrels of various commodities into the store, sweeping the floor, handling live animals, etc. This, to be sure, is a hardship to the worker. It is a menace to the people who buy and eat the food so handled.

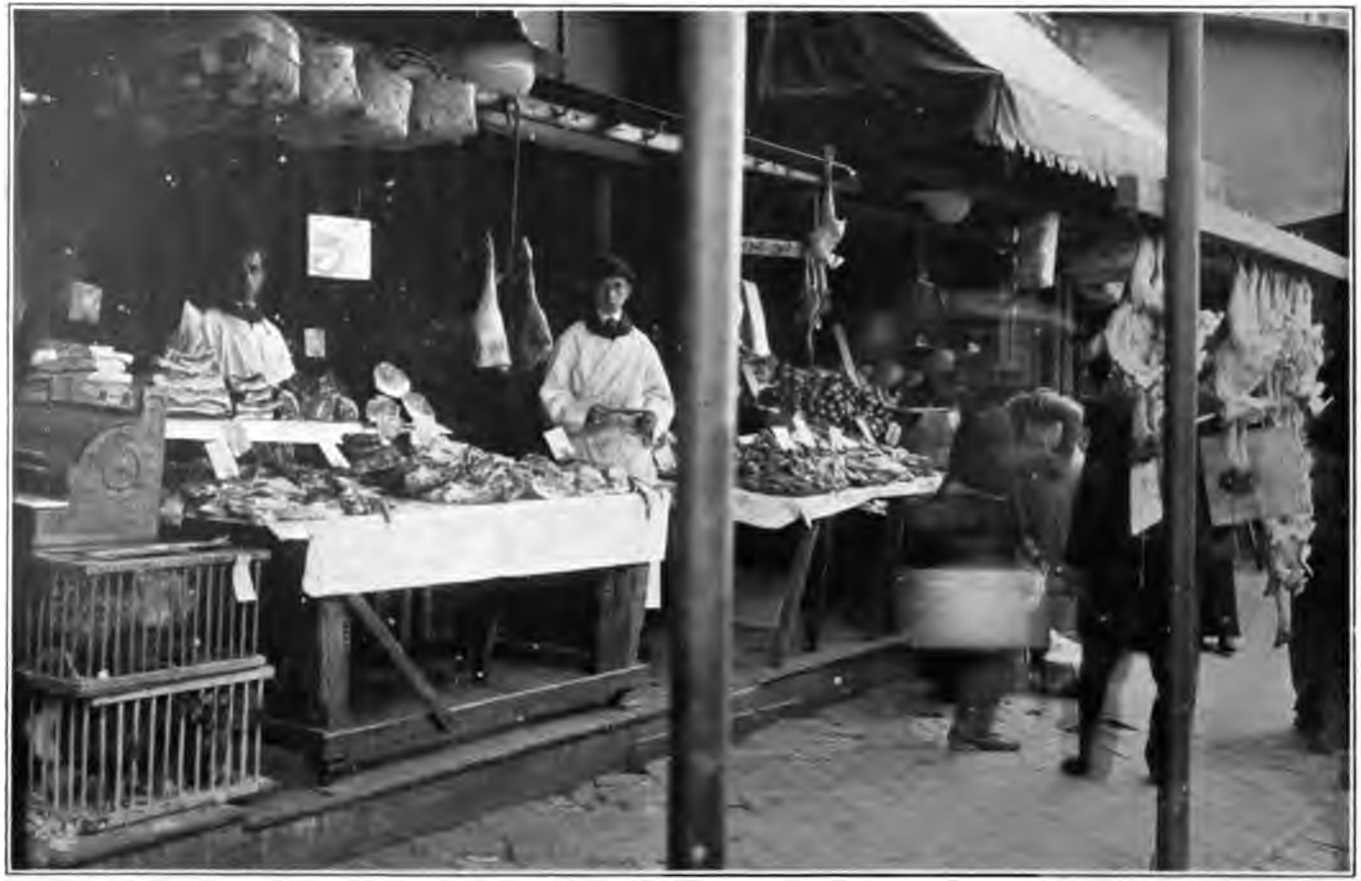
The great majority of businesses, 89.8 per cent., are conducted in buildings especially constructed for store purposes, Exhibit 13; some few, however, are conducted in buildings of another type—residence, factory, or tenement, 3.5 per cent., 2 per cent., and 3.7 per cent. respectively. Of these, groceries form the most frequent exceptions, 12 being conducted in residences and 15 in tenements; 9 of the 21 businesses conducted in factories are bakeries.

In the investigation of the stores, ventilation, light, natural and artificial, screening, and evidences of expectoration were scored for both the front room or store of the establishment and also the workroom. Eight stores were not scored at all for buildings, so that the total used for the front rooms in these tables, Exhibits 14 and 15, is 1022. Only 292 of these stores had workrooms other than the main store itself, so that for workrooms this was the total used.

Ventilation and lighting, both natural and artificial, are good in more than half of the cases studied for front rooms, and fair in a great majority of the remaining stores; in fact over 90 per cent. are either good or fair. The workrooms are not so well provided for, however, and the ventilation here is bad or very bad in 45 per cent. of the cases, the natural light poor in 48 per cent., and even artificial light poor in 45 per cent. of the rooms.

Evidences of expectoration were very prevalent in the main store rooms in about 40 per cent. of the stores investigated, Exhibit 15. A filthy habit at best, it becomes revolting when it comes so close to our food supply.

One of the worst conditions in the stores, and a very general one through-



Photograph No. 5.—Street exposure of meats and poultry in violation of the law.

out the city, is the lack of screening or covering the food to protect it from domestic animals, flies, and other insects, and from handling by prospective buyers. Fruit, cakes, pies, bread, candy, and other foods eaten without further preparation or cooking are everywhere exposed. Meat hangs up or lies on the counter for hours subject to flies and the handling of passers-by. (Photograph No. 5.) Many women, it seems, have the habit of poking or pinching meat before they buy it, a dangerous as well as a disgusting practice. In only 52 per cent. of the stores studied was provision made for covering foods requiring it with net screens or glass cases. A comparison of the general, shop, and food scores for the 1030 stores, Exhibit 16, gives the following per cent. of the establishments a score of 7 or above:

General score	74.7 per cent.
Shop score	89.3 per cent.
Food score	56.9 per cent.

Taking these scores by the various types of buildings we get the following:

	Residence	Store	Factory	Tenement
General score	77.8	74.4	95.2	63.1
Shop score	88.9	89.2	100.0	84.2
Food score	66.7	61.9	90.4	36.9

The factories and residences give the best results, therefore, and the tenements by far the worst.

Various nationalities are represented in this investigation—Hebrew 43 per cent., Afro-American 2 per cent., American 15 per cent., Italian 21 per cent., German 8 per cent., Irish 3 per cent., and miscellaneous 8 per cent. Exhibit 16 shows what percentages of these nationalities carry on the various kinds of business. The grocery business seems quite popular with people of all nationalities, having the highest percentage for each nationality except the Germans, where bakeries lead. Meat stores seem to be the next popular with Hebrews, Americans, and the Irish, provisions and restaurants tie for second place with the negroes, and meat and provisions come second with Italians, each constituting 14 per cent. of the Italian establishments. Taking the various businesses in the order of their frequency we have:

	Number	Per Cent.
Grocery	398	38.6
Meat	182	17.7
Bakery	112	10.9
Provisions	100	9.7
Confectionery	96	9.3
Creamery	64	6.2
Restaurant	35	3.4
Fish	30	2.9
Ice cream	13	1.3

No definite conclusion can be arrived at as to the influence of the length of stay in the country upon the kind of business entered upon. Exhibit 17 shows, however, that most of the people in business have been here at least ten years. It probably requires some time for the immigrant to be able to set up in business for himself. Of the people born in the United States, moreover, the grocery business seems to be the least popular of any, only 18.6 per cent. of such establishments being conducted by people born here. Bakeries seem to be next in disfavor, creameries next, etc. (See Exhibit 17.)

In taking up the general score according to nationalities, Exhibit 18, some interesting results are obtained. Of the entire number of stores studied, 74.7 per cent. had a general score of 7 or over. Treating the nationalities separately, the following results are obtained:

NATIONALITY	TOTAL NO.	NO. ABOVE 7	PER CENT. ABOVE 7
American	158	148	93.7
Irish	27	25	92.6
German	84	74	88.1
Hebrew	442	299	67.6
Italian	215	145	67.5
Afro-American	20	10	50.0
Miscellaneous	84	69	82.1
Total	1030	770	74.7

These exhibits with their fund of information are a strong plea for increased regulation and better inspection of our food supply. Evidences of active unofficial interest in the subject are not wanting. It is a subject in which such interest is contagious and effective. At the beginning of this study one of the large stores, Gimbel Brothers, exposed all of their foods, many of them delicatessen products. Through the influence of one of the workers on the survey, however, they were persuaded to provide glass cases for their foods and now everything is covered and the store is one of the best in the city in this respect.

Distribution of Shops.—The various sections of the city chosen for this study are shown in Exhibits 20 to 28 inclusive. These maps illustrate graphically several factors of the survey, nationality and score, type of shop and score, and business and score.

In the Second Street Market section, Polish, Jewish, German, and American owned stores are found, some of them with very low scores and none with very high ones. The section is principally a Jewish colony, with Poles on the east and Germans on the west. It is evident from the large number of food stores in a small area that the congestion contributes to the generally low score. A number of stores are kept in private residences, but most are specially constructed, Exhibits 20, 21, and 22.

The North Penn district has mostly Jewish storekeepers, although some Germans and Italians may be found, Exhibits 20, 21, and 22. Meat stores predominate, and the type of store most often found is the usual built one.

In the Nicetown section studied, Exhibits 20, 21, and 22, all but one of the storekeepers were Polish. Meat stores are in the majority and general scores are low. All the buildings were constructed especially for store purposes.

The stores on Lancaster Avenue are kept principally by Americans and the scores are generally high. The one very low score on the map is for an Italian fruit and provision store. Meat stores predominate, and each store has been specially built, Exhibits 20, 21, and 22.

The southwest section presents considerable variety in race of owner, kind of food handled, and general score. The type of building is of the usual store construction or combined residence and store. There are few generalizations to be made here; the data give a good illustration of the personal equation in storekeeping, Exhibits 20, 21, and 22.

In the South Front Street Polish section, Exhibits 23, 24, and 25, most of the storekeepers are Polish, as evidenced by the number of "P's" on the map. The square block on Swanson Street locates an American-owned ice-cream factory, and, as such, is not local in character. With this exception all storekeepers are Polish or Polish-speaking Jews. Grocery stores are the most common, and as usual the built store predominates, although tenements and residences used as stores are in evidence.

Most stores in the Italian study, in the southeastern section of the city, are owned by Italians, but there is also a sprinkling of Jewish and American stores here. The built store is most frequently found and the grocery business is the most common. As usual the scores are low as in most of the congested sections, Exhibits 23, 24 and 25.

The Kensington storekeepers are largely Americans and practically all kinds of stores are represented in this district, Exhibits 23, 24, and 25. The buildings are as usual constructed for use as stores and the scores are generally fair.

In the South Philadelphia Jewish study practically all the storekeepers are Jewish, with just a few Americans and Germans on the borders of the section. The store in a tenement is more common here than in the other districts investigated, but the combined store and residence or specially built store is the type usually met with. Grocery stores predominate, but all the different kinds of food stores are well represented. General scores are low in the congested sections, Exhibits 26, 27, and 28.

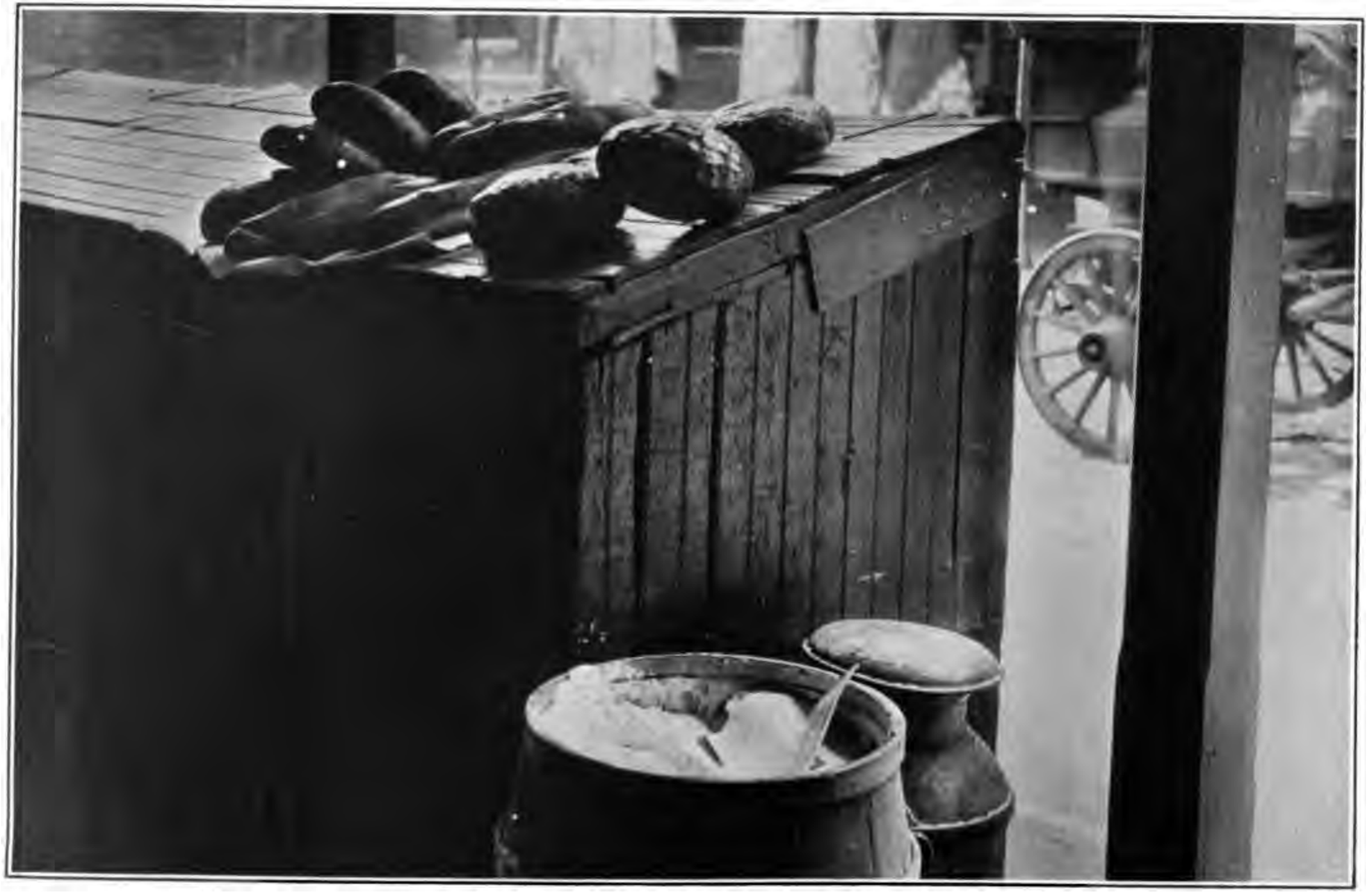
Many storekeepers in the Afro-American section, principally in the 7th ward, are Jewish, the negroes themselves inclining toward the restaurant business. The general scores are very low, due no doubt to congestion and the grade of food handled. Meat stores predominate, but a large number also sell other kinds of food. Built stores as usual are the most common, Exhibits 26, 27, and 28.

The larger establishments studied, Finley Acker Company, Gimbel Brothers, Mitchell, Fletcher & Company, etc., are not shown on the maps, since they did not fall in the districts with the smaller stores. Conditions here, however, are on the whole better than in the general run of stores.

Municipal Markets.—While conditions in the stores are far from satisfactory, those in the municipal markets are much worse, and this is less justifiable than carelessly conducted stores. The sheds are old and entirely open and not the slightest attempt is made to screen them from the flies in summer or from the street dust all the year round. The Bureau of Health has refused to license stalls there for the last four years, yet they continue in business nevertheless. Practically all the food is exposed—bread, cake, meats, poultry, pickles, etc., and in one instance even a barrel of flour. (Photograph No. 6.) Customers finger the food and brush against it as they pass, for the aisles between stalls are narrow and very often crowded. Dogs and cats have easy access, in fact there is no way to keep them out, and much to attract them. There are no worse conditions in the city than exist here. Investigation of one of the stalls in the South Second Street Market, where the proprietor said that he has government, state, and municipal inspection, disclosed a huge piece of beef, "soft to the point of sponginess, terribly discolored, part of it slimy and part entirely dried up." The man assured the investigator that this "would not be sold to his customers but was shortly to be called for by a bologna sausage maker. Large halves of mutton were hanging out on the open side of the market above the gutter, and they were very dry and dirty looking." Vegetables are often piled directly upon the ground and dressed fowl hang along the edges of the market directly over filthy gutters and so low that people entering the market constantly brush against them.

Push-carts.—The push-cart problem also deserves serious consideration. More than half of the 194 studied, Exhibits 29 and 30, had a general score and food score of less than 7. They are conducted by men and women of various nationalities, Italians, however, conducting 33 per cent. of those studied. Jewish vendors come second with 21.1 per cent. of the carts.

The length of time that a vendor lives in the United States does not seem to have any special effect upon the general condition of his cart,



Photograph No. 6.—Exposure of bread and flour, also can of milk. Municipal market.

Exhibit 31. The following are the percentages under 7 according to the length of stay in this country:

TIME IN UNITED STATES	GENERAL SCORE UNDER 7
4 months	53.6 per cent.
4 months–1 year	100.0 per cent.
1 year–2 years	40.0 per cent.
2 years–5 years	66.7 per cent.
5 years–10 years	58.3 per cent.
10 years–15 years	42.9 per cent.
15 years–20 years	57.6 per cent.
20 years–25 years	64.2 per cent.
25 years	50.1 per cent.
Born in United States	61.3 per cent.

Many kinds of food are vended on push-carts—milk, poultry, meat, fish, vegetables, butter and cheese, confectionery, bread, pastry, dried fruits, fruit, eggs, and ice cream. Fruit and vegetables, however, are the most common, Exhibit 32. More than half of the carts, 53.3 per cent., handle only one kind of food, Exhibit 33, while 43.2 per cent. deal in two commodities and 3.5 per cent. handle three or more. The food score is 7, or more for only 50.5 per cent. of the carts and of the carts with this passing score 60 per cent. handle only one kind of food. The combination of fruit and vegetables, Exhibit 34, is quite usual, 83.2 per cent. of the carts carrying two kinds of food dealing in these commodities.

So far as handling the food is concerned and also exposure to dust and flies, Exhibits 35 to 38, the carts and stands conducted by Hebrews and Italians are the worst and, as a rule, Americans the best. About 75 per cent. of the carts are rated bad or very bad for exposure to dust, over 45 per cent. for handling, and 59 per cent. for flies. Twenty-seven per cent. have animals around, and here also the Hebrews and Italians have the lowest ratings, although the Italians also register the highest per cent. of good carts so far as this factor is concerned, Exhibits 37 and 38.

As to the condition of preservation, Exhibits 39 and 40, 38 per cent. are good, 46 per cent. fair and 14 per cent. bad or very bad. Here the Italians are again the worst offenders, although they also have the highest percentage of good carts. The Hebrew carts rank high in preservation also, 20 per cent. of all the good carts belonging to proprietors of this nationality.

Most of the push-carts, 179, are conducted by men, Exhibit 41, and 16 by women, and the health and general appearance of these workers, Exhibit 42, is bad or very bad in 36 per cent. of the cases, while in only 14 per cent. is it good. The dealers in vegetables and fruit are rated lowest as to health and general appearance.

Exhibit 43 shows the relation between the sanitary condition of the carts and the health and general appearance of the workers. The majority of those having good or fair health have a sanitary score of above 7, while most of those in bad health and poor personal appearance have low sanitary scores. This would seem to be an especially dangerous combination. In about 55 per cent. of the cases under consideration the rating for sanitary conditions of the cart was less than 7. Vegetables and fruit contribute heavily to this score, as do also fish, bread and pastry, Exhibit 44.

The carts are, as a rule, kept in repair—only about 7 per cent. being in bad condition, while 27 per cent. were in good condition and the rest fair, Exhibit 45. Only about 18 per cent. of the carts were clean, however, 52.3 per cent. were fair, and 28 per cent. were definitely dirty, Exhibit 45.

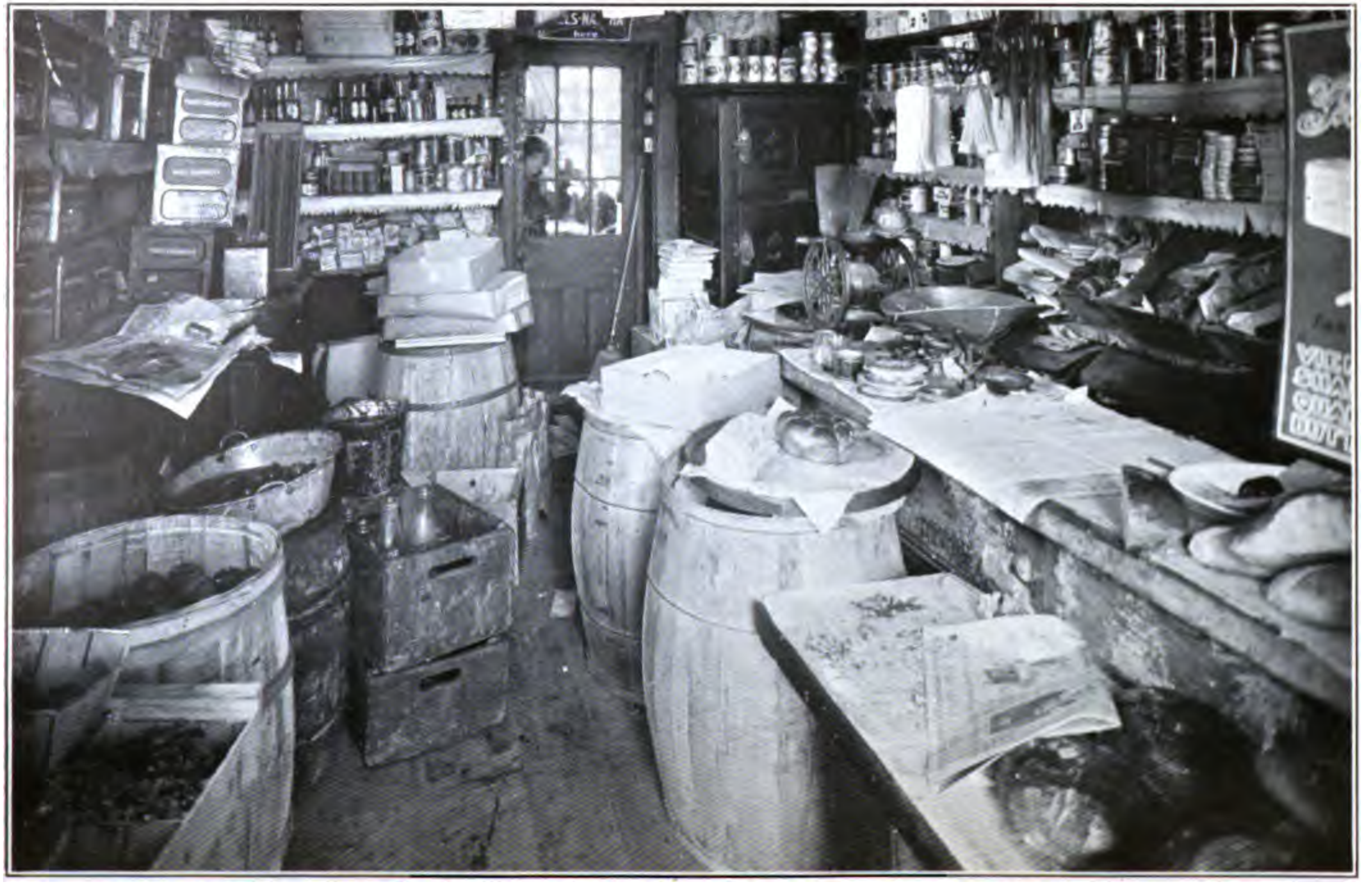
The surroundings of the carts are in general rather poor, the score for condition of the street being bad or very bad in 31 per cent. of the cases and that for the condition of gutters bad in two-thirds of the cases, Exhibit 46. In 71.7 per cent. of the cases studied there was surface drainage in the vicinity of the carts.

Exhibit 48 gives the distribution of the push-carts studied.

The condition under which the food is stored over night or for longer periods when it is bought in large quantities is a very important factor so far as health is concerned, and was made the subject of a special study. In only a very few cases was it found to be kept in clean places specially provided for this purpose. Far more often is it stored in filthy cellars, or in kitchens, piled up on chairs, or even in bedrooms. In a number of cases it is left in the carts, which stand out almost anywhere, in yards or alleys or in push-cart stables, covered with soiled strips of oilcloth.

School Yard Vendors.—In addition to the men conducting push-carts and stands along the streets are the special vendors who go directly to school yards with their cakes, candies, and nuts, and take up their positions there at recess and lunch times. (Photograph No. 7.) They are always well patronized by the children, who naturally do not realize the danger lurking in the dirty cakes and candies. It is very unusual for these vendors to cover their wares. Although the basket may have lids, they are always propped open. In all cases, also, the baskets are set down on the ground. (Photograph No. 8.) These vendors are frequently persons in poor health, not able to engage in a regular occupation, so they eke out a livelihood in this way. It is, however, very poor economy for society to permit this, for while otherwise it would probably have to keep the vendor, as it is now it may have to take care of many sick persons who may become infected by the impure, disease-laden food. In the course of this investigation a follow-up home investigation of a street vendor dealing in shelled nuts disclosed the fact

Photographs Nos. 7 and 8.—"Food vendors—cakes, pretzels, candies, etc., displayed on sidewalk. No protection against dust, flies, etc., and not even raised above street level. Of the type frequenting school yards."



Photograph No. 9.—Interior exposure of perishable foods.

that the man was in the advanced stages of tuberculosis and grossly careless in his habits. This man himself shelled and handled the nuts which he sold.

The importance of establishing and enforcing sanitary standards for this trade cannot be too strongly emphasized. At the present time licenses to Food Vendors are issued by the Department of City Property on the purely commercial basis of meeting the license fee of $1.00. The Department of Health exercises no power of supervision nor are any sanitary requirements or regulations made.

Thus, with these vendors permitted free access to school yards and school children, the purpose and effectiveness of our school medical inspection system is, to some extent, nullified. School principals, alive to the dangers of this practice, have urged the Board of Education to pass prohibitory regulations. So far, however, concerted effort has failed, and whatever preventive measures are taken must emanate from the Department of Health. In New York City the Health Department has inaugurated a definite and regular campaign of education and, among other things, uses a model pushcart, properly glassed and screened, as an object-lesson to the vendors.

The only way to correct this evil seems to lie in the direction of enacting and enforcing, by license, strict sanitary provisions covering the health and personal cleanliness of the vendor and the proper handling and storing of the food at all times.

Street Exposure of Foods.—Practically all kinds of food are exposed in the stores—meat, fish, poultry, vegetables, fruit, dried fruits and vegetables, milk, confectionery, bread, etc. Many also are on the streets without protection, particularly fruit and vegetables, dried fruits, and poultry. (Photographs Nos. 9, 10, and 11.) These foods, even though they may be washed and well cooked before they are eaten, very often have the dirt so ground into them that it is practically impossible to wash them clean.

In the course of this study several authorities on the danger and extent of contamination of foods that require to be cooked were consulted. While there is a difference of opinion as to the extent of this danger, all agree on the need for protection.

Another custom especially prevalent in the poorer and more congested sections of the city is the above-mentioned use of newspaper for wrapping the foods. (Photograph No. 18.) This is in violation of a ruling of the Board of Health, but is still very much in practice when the food inspectors are not in sight. *There are over 10,000 food stores in Philadelphia and but a very limited number of food inspectors to cover the field (see section II), so that it is unusual for a store to be visited more than three or four times a year.*

The proprietors have plenty of leeway to evade the law, particularly those dealing in foods that are not included in the Department of Inspection, namely, milk, meat, and fish.

Legislation.—The present inspection force but very inadequately enforces the laws and ordinances referring to meat and milk which we already have, and yet there is a great need of further legislation to protect those foods which are as yet unregulated. To suppose that milk and meat are the only foods which need public control is to show a fundamental ignorance of conditions or social indifference. Why the handling of certain foods should be regulated and others left untouched, why some dealers, as they see it, are discriminated against and not others, is almost as incomprehensible to us as to them.

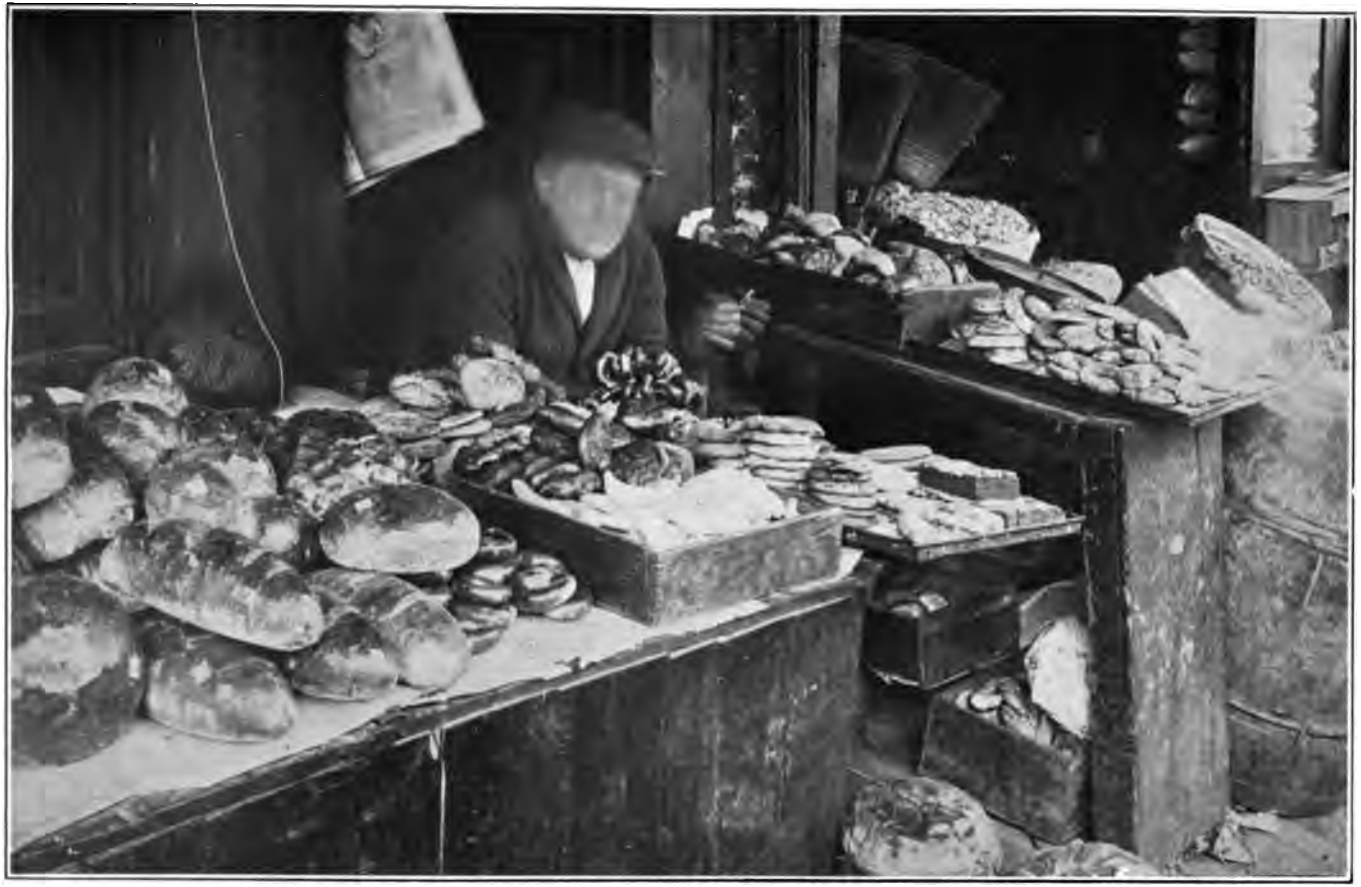
New laws should be made which would include all foods, and provision should be made for the appointment of a sufficient number of competent inspectors to see that the laws are enforced. Four bills were introduced in the last legislature to further the protection of food, providing for: (1) The establishment of a municipal abattoir—House bill No. 1303; referred to committee April 6, 1915. (2) The protection of foods against contamination from street exposure—Senate bill No. 149; referred to committee February 8, 1915. (3) The registration with the Bureau of Health of all places handling foods of any kind—House bill No. 1307; referred to committee April 6, 1915. (4) Amending § 1–3, Act April 26, 1907, regulating the licensing of slaughter-houses to include all food-handling places and conveyances, and empowering the Bureau of Health to enact rules and regulations governing the sanitary requirements of the same—Senate bill No. 985; referred to committee April 20, 1915.

All of these bills, so necessary for the protection of our food supply, died in the Health and Sanitation Committees with the exception of the second, which was defeated in the Senate.

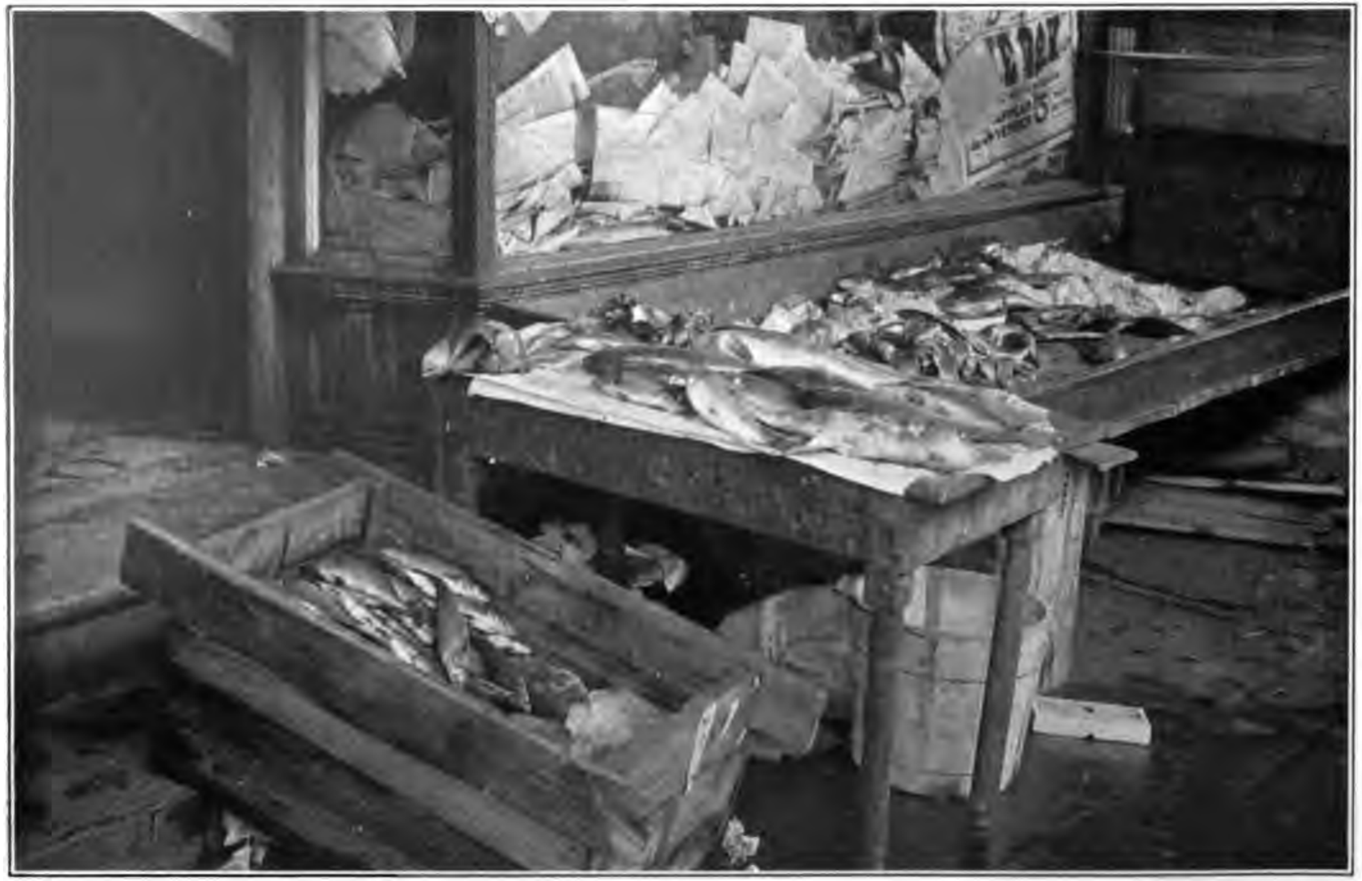
A bill, introduced by the State Live Stock Sanitary Board, was passed, however, and prohibits the handling of meats by prospective patrons. Whether this law is enforced, and how, has not yet been demonstrated.

Organization Needed.—More could be accomplished in this field, no doubt, if there were in Philadelphia a Public Health Council or Committee composed of the chief health officers of the city and a number of interested trained and influential citizens. With this council constantly at work on this and other health problems much could be accomplished which now seems impossible, although many individual workers are untiring in their efforts.

Food Exhibit.—It is hoped that in the near future it will be possible to hold a food exhibit and thereby stimulate public interest on this subject.



Photograph No. 1c.—Street exposure of bread, cakes, and pastries. Newspapers in doorway for wrapping purposes. Attendant unclean and smoking.

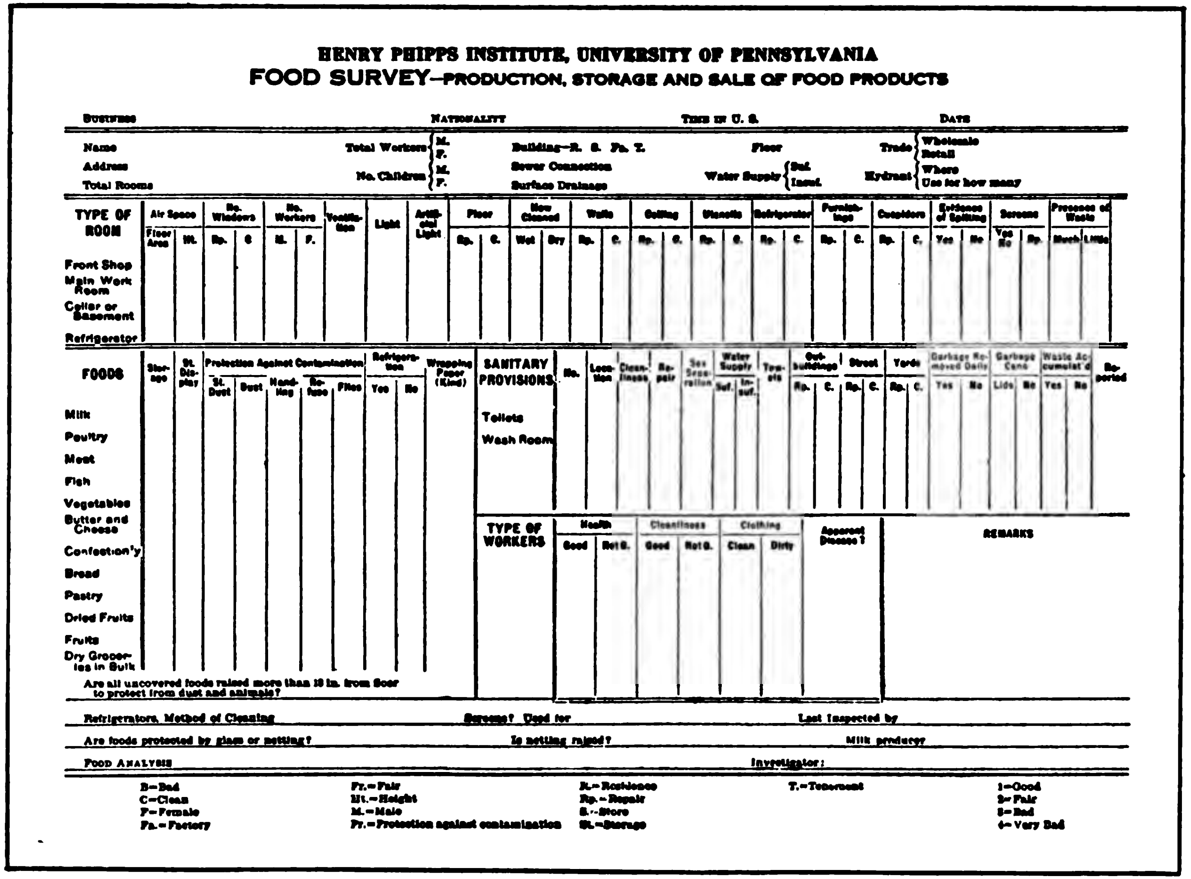


Photograph No. 11.—Street exposure and general neglect of fish-stand—no screening, and infested with flies. Newspaper for wrapping purposes.

Unless the people as a whole are awake and interested little can be accomplished.

The following associations have agreed to co-operate in this exhibit: Bureau of Health, Bureau of Municipal Research, Bureau for Social Research, Child Federation, Civic Club, Home and School League, Home Economic Association, Laboratory of Hygiene—University of Pennsylvania, School Lunch Association, Wharton School—University of Pennsylvania, and all the women's clubs.

Any activity for the suppression of disease, poverty, and vice is worthy of our most earnest attention and our most effective action.



HENRY PHIPPS INSTITUTE, UNIVERSITY OF PENNSYLVANIA

FOOD SURVEY—PRODUCTION, STORAGE AND SALE OF FOOD PRODUCTS

BUSINESS NATIONALITY TIME IN U. S. DATE

Name
Address
Total Rooms

Total Workers { M. F.
No. Children { M. F.

Building—R. S. Fa. T.
Sewer Connection
Surface Drainage

Floor
Water Supply { Suf. Insuf.

Trade { Wholesale Retail
Hydrant { Where Use for how many

TYPE OF ROOM	Air Space		No. Windows		No. Workers		Ventilation	Light	Artificial Light	Floor		How Cleaned		Walls		Ceiling		Utensils		Refrigerator		Furnishings		Cuspidors		Evidence of Spitting		Screens		Presence of Waste	
	Floor Area	Ht.	Rp.	C	M.	F.				Rp.	C.	Wet	Dry	Rp.	C.	Rp.	C.	Rp.	C.	Rp.	C.	Rp.	C.	Rp.	C.	Yes	No	Yes No	Rp.	Much	Little
Front Shop																															
Main Work Room																															
Cellar or Basement																															
Refrigerator																															

FOODS	Storage	St. Display	Protection Against Contamination					Refrigeration		Wrapping Paper (Kind)
			St. Dust	Dust	Handling	Refuse	Flies	Yes	No	
Milk										
Poultry										
Meat										
Fish										
Vegetables										
Butter and Cheese										
Confection'y										
Bread										
Pastry										
Dried Fruits										
Fruits										
Dry Groceries in Bulk										

Are all uncovered foods raised more than 18 in. from floor to protect from dust and animals?

SANITARY PROVISIONS	No.	Location	Cleanliness	Repair	Sex Separation	Water Supply		Towels	Outbuildings		Street		Yards		Garbage Removed Daily		Garbage Cans		Waste Accumulat'd		Reported
						Suf.	Insuf.		Rp.	C.	Rp.	C.	Rp.	C.	Yes	No	Lids	No	Yes	No	
Toilets																					
Wash Room																					

TYPE OF WORKERS	Health		Cleanliness		Clothing		Apparent Disease?
	Good	Not G.	Good	Not G.	Clean	Dirty	

REMARKS

Refrigerators, Method of Cleaning Screens? Used for Last Inspected by

Are foods protected by glass or netting? Is netting raised? Milk producer

Food Analysis Investigator:

B—Bad
C—Clean
F—Female
Fa.—Factory

Fr.—Fair
Ht.—Height
M.—Male
Pr.—Protection against contamination

R.—Residence
Rp.—Repair
S.—Store
St.—Storage

T.—Tenement

1—Good
2—Fair
3—Bad
4—Very Bad

Exhibit 1.—Score Card for Store Investigations.

UNIVERSITY OF PENNSYLVANIA HENRY PHIPPS INSTITUTE

FOOD SURVEY—PUSH CARTS AND STANDS

License:

Location: District: Date:

Name: Nationality Age:

Address: " of customers: Personal appearance

Time in United States: of Vendor:

FOODS	PROTECTION AGAINST				Food Iced	Condition of Preservation	Quality	REMARKS
	Flies	Dust	Handling	Animals				
Fish								
Fruit								
Bread								
Dried Fruits								
Vegetables								

Condition of { Street: Street Sewered: Condition of Push Cart:

Condition of { Gutter: Surface Drainage: Repair:

Description: Cleanliness:

Investigator.

Exhibit 2.—Score Card for Push-cart Investigations.

EXHIBIT 3.—KINDS OF BUSINESS ACCORDING TO SHOP SCORE

Stores

Score	Total		Grocery		Bakery		Meat		Fish		Creamery		Ice Cream		Provisions		Confectionery		Restaurant	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Total	1030	..	398	38.6	112	10.9	182	17.7	30	2.9	64	6.2	13	1.3	100	9.7	96	9.3	35	3.4
1	1	.1	..	..	..	..	..	..	..	..	..	..	..	..	1	1.0	..	..	..	..
2	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
3	1	.1	..	..	..	..	..	..	..	..	..	..	..	..	1	1.0	..	..	..	..
4	14	1.4	4	1.0	..	..	5	2.7	1	3.3	..	..	..	..	2	2.0	1	1.0	1	2.9
5	27	2.6	7	1.8	2	1.8	5	2.7	3	10.0	1	1.6	..	..	8	8.0	..	..	1	2.9
6	67	6.5	28	7.0	4	3.6	9	4.9	2	6.7	1	1.6	1	7.7	16	16.0	4	4.2	2	5.7
7	221	21.4	99	24.9	21	18.7	33	18.1	4	13.3	9	14.0	1	7.7	33	33.0	15	15.6	6	17.1
8	310	30.1	121	30.4	49	43.8	56	30.8	3	10.0	23	36.0	7	53.9	19	19.0	18	18.8	14	40.0
9	255	24.8	96	24.1	27	24.1	40	22.0	14	46.6	23	36.0	3	23.0	17	17.0	31	32.3	4	11.4
10	132	12.8	43	10.8	8	7.1	34	18.7	3	10.0	7	10.8	1	7.7	3	3.0	27	28.1	6	17.1
Not given	2	.2	..	..	1	.9	..	..	..	..	..	..	..	..	..	..	..	..	1	2.9

EXHIBIT 4.—FOODS HANDLED ACCORDING TO FOOD SCORE

Stores

Food Score	Total		Dry Groceries		Fruit		Dried Fruit		Pastry		Bread		Confectionery		Butter and Cheese		Vegetables		Fish		Meat		Poultry		Milk	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Total	3,258	..	375	11.5	286	8.8	158	4.8	208	6.4	475	14.5	291	9.0	325	10.0	313	9.6	229	7.0	328	10.0	115	3.5	155	4.7
1	192	5.9	13	3.5	38	13.2	11	6.9	5	2.4	18	3.8	6	2.1	4	1.2	39	12.4	24	10.5	15	4.7	17	14.7	2	1.3
2	48	1.5	4	1.1	6	2.1	4	2.5	1	.5	7	1.5	..	..	3	.9	4	1.2	8	3.5	5	1.6	4	3.5	2	1.3
3	217	6.7	23	6.1	29	10.1	18	11.4	8	3.8	27	5.7	10	3.4	19	5.8	26	8.3	24	10.5	23	7.0	9	7.8	1	.6
4	279	8.6	30	8.0	32	11.1	19	12.0	10	4.8	36	7.6	13	4.4	27	8.3	27	8.6	27	11.8	36	11.0	17	14.7	5	3.2
5	354	10.8	38	10.1	37	12.8	24	15.2	19	9.2	51	10.7	24	8.3	35	10.7	39	12.4	22	9.6	41	12.5	15	13.0	9	5.8
6	309	9.4	34	9.1	24	8.4	21	13.3	23	11.0	49	10.3	19	6.5	30	9.2	33	10.5	26	11.3	28	8.5	7	6.1	15	9.7
7	460	14.1	48	12.8	37	12.9	21	13.3	33	15.8	79	16.6	38	13.0	46	14.2	43	13.7	29	12.7	48	14.6	17	14.7	21	13.5
8	475	14.5	59	15.7	39	13.7	21	13.3	33	15.8	73	15.3	42	14.4	49	15.1	46	14.7	34	14.8	49	14.9	10	8.7	20	12.9
9	383	11.7	53	14.1	28	9.8	11	6.9	24	11.5	61	12.8	32	11.0	56	17.2	38	12.1	12	5.2	34	10.3	6	5.2	27	17.4
10	542	16.6	73	19.5	16	5.7	8	5.0	52	25.1	74	15.5	107	36.7	56	17.2	18	5.8	23	10.0	49	14.9	13	11.4	53	34.2

EXHIBIT 5.—KINDS OF BUSINESS ACCORDING TO GENERAL SCORE

Stores

Score	Total		Grocery		Bakery		Meat		Fish		Creamery		Ice Cream		Provisions		Confectionery		Restaurant	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Total	1030	..	398	38.6	112	10.9	182	17.6	30	2.9	64	6.2	13	1.3	100	9.7	96	9.3	35	3.4
1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
2	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
3	6	.6	1	.3	..	..	2	1.1	..	..	..	..	..	..	3	3.0	..	..	..	..
4	34	3.3	4	1.0	..	..	9	4.9	1	3.3	1	1.6	..	..	15	15.0	..	..	4	11.4
5	86	8.3	33	8.3	4	3.6	17	9.3	5	16.7	..	..	1	7.7	24	24.0	1	1.0	1	2.9
6	134	13.0	52	13.1	13	11.6	25	13.7	3	10.0	6	9.5	..	..	24	24.0	8	8.3	3	8.6
7	213	20.7	107	26.9	29	25.9	38	20.9	2	6.7	10	15.6	1	7.7	14	14.0	5	5.2	7	20.0
8	251	24.3	96	24.1	38	33.9	40	22.0	7	23.3	24	37.8	6	46.2	12	12.0	18	18.8	10	28.6
9	245	23.8	89	22.3	24	21.4	40	22.0	9	30.0	17	26.9	5	38.4	7	7.0	48	50.0	6	17.1
10	61	5.9	16	4.0	4	3.6	11	6.0	3	10.0	6	9.5	..	..	1	1.0	16	16.7	4	11.4

EXHIBIT 6.—FOODS ACCORDING TO SCORE FOR SURROUNDINGS

Stores

Food Score	Total		Dry Groceries		Fruit		Dried Fruit		Pastry		Bread		Confectionery		Butter and Cheese		Vegetables		Fish		Poultry		Meat		Milk	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Total	3,258	..	375	11.5	286	8.8	158	4.8	208	6.4	475	14.5	291	9.0	325	10.0	313	9.6	229	7.0	115	3.5	328	10.0	155	4.7
1	3	0.1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2	1.7	1	.3	..	..
2	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
3	12	.4	1	.3	..	..	..	..	..	..	..	..	1	.3	1	.3	..	..	2	.9	3	2.6	2	.6	2	1.3
4	51	1.6	4	1.1	6	2.1	2	1.3	4	1.9	10	2.1	2	.7	2	.6	4	1.3	5	2.2	3	2.6	4	1.2	5	3.2
5	213	6.5	26	6.9	25	8.7	11	7.0	10	4.8	29	6.1	10	3.4	16	4.9	22	7.0	22	9.6	10	8.7	13	4.0	19	12.2
6	322	9.9	27	7.2	29	10.1	18	11.4	24	11.5	42	8.8	22	7.6	34	10.5	39	12.5	24	10.5	19	16.5	36	11.0	8	5.1
7	1,114	34.2	111	29.6	119	41.6	77	48.8	57	27.4	148	31.2	80	27.6	110	33.8	130	41.5	93	40.6	41	35.6	115	35.1	33	21.2
8	713	21.8	82	21.8	58	20.1	28	17.7	47	22.6	113	23.8	72	24.9	75	23.1	68	21.8	39	17.0	19	16.5	72	22.0	40	25.9
9	458	14.0	73	19.5	30	10.5	14	8.8	30	14.4	75	15.8	53	18.2	50	15.4	29	9.3	21	9.2	8	7.0	47	14.3	28	18.1
10	348	10.7	48	12.8	18	6.3	8	5.0	34	16.4	56	11.8	49	16.5	35	10.7	19	6.1	22	9.6	8	7.0	32	9.7	19.	12.2
Not given	24	.7	3	.8	1	.3	..	..	2	1.0	2	.4	2	6.7	2	.6	2	.6	1	.4	2	1.7	6	1.8	1	.7

EXHIBIT 7.—FOODS HANDLED ACCORDING TO SANITATION SCORE

STORES

SCORE	TOTAL		DRY GROCERIES		FRUIT		DRIED FRUIT		PASTRY		BREAD		CONFECTIONERY		BUTTER AND CHEESE		VEGETABLES		FISH		POULTRY		MEAT		MILK	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Total..........	3,258	..	375	11.5	286	8.8	158	4.8	208	6.4	475	14.5	291	9.0	325	10.0	313	9.6	229	7.0	115	3.5	328	10.0	155	4.7
1............	13	.4	2	.5	2	.7	2	1.3	..	..	1	.2	1	.3	..	..	2	.6	3	1.3	..	..	..	..	..	..
2............	1	.03	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	.4	..	..	..	..	..	..
3............	38	1.1	3	.8	7	2.4	1	.6	1	.5	4	.8	2	.7	..	..	7	2.2	6	2.6	1	.9	4	1.2	2	1.3
4............	181	5.5	23	6.1	22	7.7	12	7.6	8	3.8	25	5.3	13	4.4	18	5.6	22	7.3	13	5.7	8	7.0	10	3.0	7	4.5
5............	563	17.3	70	18.7	57	19.9	33	20.9	22	10.6	74	15.6	51	17.5	57	17.6	66	21.0	37	16.2	22	19.1	49	14.9	25	16.1
6............	845	25.9	83	22.1	80	28.1	41	25.9	58	27.9	114	24.0	72	24.8	89	27.4	82	26.1	66	28.8	32	27.8	87	26.5	41	26.5
7............	658	20.2	65	17.3	53	18.5	32	20.2	45	21.7	103	21.7	61	21.0	64	19.7	60	19.2	51	22.3	22	19.1	72	22.0	30	19.4
8............	583	17.9	84	22.4	37	12.9	21	13.3	44	21.2	100	21.1	58	19.9	62	19.1	49	15.7	29	12.7	14	12.2	58	17.7	27	17.4
9............	232	7.2	26	6.9	15	5.2	9	5.7	19	9.1	36	7.6	25	8.6	19	5.8	15	4.8	17	7.4	10	8.7	23	7.0	18	11.6
10............	87	2.7	12	3.2	7	2.4	6	3.8	8	3.8	11	2.3	6	2.1	12	3.7	5	1.6	3	1.3	5	4.3	8	2.4	4	2.5
Not given......	57	1.7	7	1.9	6	2.1	1	.6	3	1.4	7	1.5	2	.7	4	1.2	5	1.6	3	1.3	1	.9	17	5.2	1	.6

EXHIBIT 8.—GROUPS OF WORKERS ACCORDING TO SANITATION SCORE—I—MALES

STORES

SCORE	TOTAL		1		2		3–5		6–9		10–14		15–19		20–25		26–32		33 UP	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Total.......	905	..	471	52.2	195	21.5	179	19.8	36	4.0	6	0.7	4	0.4	3	0.3	1	0.1	10	1.1
1..........	4	0.4	1	0.2	3	1.6	..	..	..	..	..	..	..	..	..	..	..	..	..	..
2..........	1	0.1	..	..	..	..	1	0.6	..	..	..	..	..	..	..	..	..	..	..	..
3..........	10	1.1	4	0.8	4	2.1	2	1.1	..	..	..	..	..	..	..	..	..	..	..	..
4..........	55	6.1	24	5.1	15	7.8	13	7.3	3	8.4	..	..	..	..	..	..	..	..	..	..
5..........	148	16.4	77	16.3	33	16.9	35	19.5	2	5.5	..	..	1	25.0	..	..	..	..	..	..
6..........	219	24.2	125	26.6	37	19.0	42	23.4	10	27.8	3	50.0	1	25.0	..	..	..	..	1	10.0
7..........	178	19.7	93	19.7	40	20.5	35	19.5	10	27.8	..	..	..	..	..	..	..	..	..	..
8..........	162	17.9	87	18.4	33	16.9	32	17.8	7	19.2	1	16.6	1	25.0	1	33.0	..	..	..	..
9..........	83	9.2	34	7.2	21	10.2	18	10.0	3	8.4	1	16.7	1	25.0	2	67.0	..	..	3	30.0
10..........	20	2.2	12	2.5	1	0.6	..	..	1	3.2	1	16.7	..	..	..	..	1	100.0	4	40.0
Not given ...	25	2.7	14	3.0	8	4.2	1	0.6	..	..	..	..	..	..	..	..	..	..	2	20.0

EXHIBIT 9.—GROUPS OF WORKERS ACCORDING TO SANITATION SCORE—II—FEMALES

STORES

	TOTAL		1		2		3–5		6–9		10–14		15–19		20–25		26–32		33 UP	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Total......	816	..	582	71.6	125	15.3	83	10.1	19	2.3	1	.1	..	..	1	.1	3	.3	2	.2
1.........	2	0.2	2	.3	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
2.........	1	0.1	1	.2	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
3.........	8	1.0	5	.8	2	1.5	1	1.2	..	..	..	..	..	..	..	..	..	..	..	..
4.........	52	6.2	38	6.6	6	4.7	5	6.0	3	15.7	..	..	..	..	..	..	..	..	..	..
5.........	146	17.9	98	16.8	30	24.0	17	20.4	1	5.3	..	..	..	..	..	..	..	..	..	..
6.........	199	24.4	135	23.2	30	24.0	23	27.8	10	52.7	..	..	..	..	..	..	1	33.3	..	..
7.........	161	19.8	116	20.0	23	19.1	19	22.9	2	10.5	..	..	..	..	..	..	1	33.3	..	..
8.........	141	17.3	107	18.4	22	17.5	9	10.8	2	10.5	1	100.0	..	..	..	..	..	..	..	..
9.........	78	9.6	60	10.3	9	7.1	8	9.6	1	5.3	..	..	..	..	..	..	..	..	..	..
10.........	20	2.4	13	2.2	2	1.5	1	1.2	..	..	..	..	..	..	1	100.	1	33.3	2	100
Not given ..	8	1.0	7	1.1	1	.7	..	..	..	..	..	..	..	..	..	..	..	..	..	..

EXHIBIT 10.—WORKERS ACCORDING TO SANITATION SCORE—III—RECAPITULATION

STORES

SCORE	TOTAL		MALE		FEMALE	
	No.	%	No.	%	No.	%
Total..................	1,721	..	905	52.6	816	47.4
1....................	6	0.3	4	0.4	2	0.2
2....................	2	0.1	1	0.1	1	0.1
3....................	18	1.0	10	1.1	8	1.0
4....................	107	6.2	55	6.1	52	6.2
5....................	294	17.1	148	16.4	146	17.9
6....................	418	24.4	219	24.2	199	24.4
7....................	339	19.7	178	19.7	161	19.8
8....................	303	17.6	162	17.9	141	17.3
9....................	161	9.4	83	9.2	78	9.6
10....................	40	2.3	20	2.2	20	2.4
Not given..............	33	1.9	25	2.7	8	1.0

EXHIBIT 11.—FOODS HANDLED ACCORDING TO WORKERS' SCORE

STORES

SCORE	TOTAL		DRY GROCERIES		FRUIT		DRIED FRUIT		PASTRY		BREAD		CONFECTIONERY		BUTTER AND CHEESE		VEGETABLES		FISH		MEAT		POULTRY		MILK	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Total	3,258	..	375	11.5	286	8.8	158	4.8	208	6.4	475	14.5	291	9.0	325	10.0	313	9.6	229	7.0	328	10.0	115	3.5	155	4.7
1	2	.06	..	..	..	..	..	..	..	..	1	.2	..	..	..	..	..	..	..	..	1	.3	..	..	..	..
2	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
3	34	1.0	3	.8	5	1.7	2	1.3	..	..	4	.8	2	.7	3	.9	6	1.9	4	1.7	3	.9	1	.9	1	.6
4	26	.8	1	.3	3	1.0	2	1.3	1	.5	2	.4	3	1.0	2	.6	4	1.3	2	.8	3	.9	3	2.6	..	..
5	238	7.3	25	6.6	26	9.1	19	12.0	8	3.8	29	6.1	15	5.2	23	7.1	24	7.7	23	10.1	26	7.9	9	7.8	11	7.1
6	247	7.6	22	5.9	25	8.7	16	10.1	9	4.3	25	5.3	16	5.5	23	7.1	29	9.3	28	12.2	24	7.3	21	18.3	9	5.8
7	237	7.3	22	5.9	27	9.4	14	8.9	18	8.7	32	6.7	14	4.8	23	7.1	27	8.7	17	7.5	26	7.9	11	9.6	6	3.9
8	700	21.5	72	19.2	77	26.9	42	26.6	34	16.3	89	18.8	48	16.5	75	23.1	87	27.8	56	24.5	69	21.0	28	24.4	23	14.8
9	471	14.7	44	11.7	38	13.3	28	17.7	33	15.9	78	16.4	43	14.8	41	12.6	48	15.3	31	13.5	47	14.3	17	14.8	23	14.8
10	1,287	39.2	184	49.1	85	29.8	34	21.5	104	50.0	212	44.7	150	51.6	133	41.0	88	28.0	65	28.4	125	38.2	25	21.7	82	53.0
Not given	16	.5	2	.6	..	..	1	.6	1	.5	3	.6	..	..	2	.6	..	..	3	1.3	4	1.2	..	..	..	..

EXHIBIT 12.—FOODS ACCORDING TO SURFACE DRAINAGE AND WATER SUPPLY

STORES

SURFACE DRAINAGE	TOTAL		DRY GROCERIES		FRUIT		DRIED FRUIT		PASTRY		BREAD		CONFECTIONERY		BUTTER AND CHEESE		VEGETABLES		FISH		MEAT		POULTRY		MILK	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Total	3,258	..	375	11.5	286	8.8	158	4.8	208	6.4	475	14.5	291	9.0	325	10.0	313	9.6	229	7.0	328	10.0	115	3.5	155	4.7
Yes	250	7.6	23	6.1	17	6.0	10	6.3	19	9.1	40	8.4	27	9.3	29	9.0	21	6.7	21	9.2	27	8.2	6	5.2	10	6.4
No	1,442	44.1	209	55.7	100	35.0	40	25.3	107	51.5	248	52.2	162	55.7	145	44.6	113	36.2	75	32.8	116	35.4	27	23.5	100	64.5
Not given	1,566	48.4	143	38.2	169	59.0	108	68.5	82	39.4	187	39.4	102	35.1	151	46.5	179	57.2	133	58.0	185	56.5	82	71.2	45	29.0
WATER SUPPLY																										
Total	3,258	..	375	11.5	286	8.8	158	4.8	208	6.4	475	14.5	291	9.0	325	10.0	313	9.6	229	7.0	328	10.0	115	3.5	155	4.7
Sufficient	2,418	74.2	289	77.1	189	66.1	104	65.7	154	74.1	373	78.6	230	79.0	249	76.6	217	69.3	171	74.6	234	71.4	79	68.7	129	83.2
Insufficient	705	21.6	76	20.3	85	29.7	48	30.4	39	18.6	79	16.4	51	17.5	69	21.2	85	27.2	51	22.3	71	21.6	31	27.0	20	12.9
Not given	135	4.1	10	2.6	12	4.2	6	3.8	15	7.2	23	4.9	10	3.4	7	2.2	11	3.5	7	3.0	23	7.0	5	4.3	6	3.8

EXHIBIT 13.—BUILDINGS ACCORDING TO KINDS OF BUSINESS

STORES

SCORE	TOTAL		GROCERY		BAKERY		MEAT		FISH		CREAMERY		ICE CREAM		PROVISIONS		CONFECTIONERY		RESTAURANT	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Total	1030	..	398	38.6	112	10.9	182	17.7	30	2.9	64	6.2	13	1.3	100	9.7	96	9.3	35	3.4
Residence	36	3.5	12	3.0	3	2.7	3	1.7	..	..	8	12.5	..	..	4	4.0	1	1.0	5	14.2
Store	927	89.8	367	92.2	91	81.2	172	94.4	30	100.0	54	84.4	10	77.0	88	88.0	88	91.7	27	77.2
Factory	21	2.0	3	.8	9	8.0	1	0.6	..	..	2	3.1	3	23.0	..	..	3	3.1	..	..
Tenement	38	3.7	15	3.8	7	6.2	5	2.7	..	..	..	..	..	..	7	7.0	3	3.1	1	2.9
Not given	8	.8	1	.3	2	1.8	1	0.6	..	..	..	..	..	..	1	1.0	1	1.0	2	5.7

EXHIBIT 14.—BUILDINGS ACCORDING TO VENTILATION, LIGHT, AND ARTIFICIAL HEAT

STORES

SCORE	VENTILATION										NATURAL LIGHT										ARTIFICIAL LIGHT									
	Total		Residence		Store		Factory		Tenement		Total		Residence		Store		Factory		Tenement		Total		Residence		Store		Factory		Tenement	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
FRONT ROOM																														
Total	1,022	..	36	3.6	927	90.2	21	2.5	38	3.7	1,022	..	36	3.6	927	90.2	21	2.5	38	3.7	1,022	..	36	3.6	927	90.2	21	2.5	38	3.7
Good	571	55.8	11	30.6	541	58.5	6	28.7	13	34.2	695	68.1	15	41.7	649	70.1	5	23.8	26	68.5	592	57.8	13	36.2	552	59.6	14	66.7	13	34.2
Fair	393	38.4	23	64.0	339	36.6	9	42.9	22	58.0	281	27.4	18	50.0	241	26.0	10	47.6	12	31.5	339	33.2	12	33.3	303	32.7	2	9.5	22	58.0
Bad	44	4.3	2	5.5	38	4.0	1	4.7	3	7.9	32	3.1	3	8.3	28	3.0	1	4.8	..	..	60	5.9	9	25.0	48	5.2	..	..	3	7.9
Very bad	3	.3	..	..	3	.3	..	..	..	..	3	.3	..	..	3	.3	..	..	..	..	5	.5	..	..	5	.5	..	..	..	..
Not given	11	1.1	..	..	6	.6	5	23.8	..	..	11	1.1	..	..	6	.6	5	23.8	..	..	26	2.5	2	5.6	19	2.0	5	23.8	..	..
WORK ROOM																														
Total	292	..	18	6.2	241	82.6	21	7.2	12	4.1	292	..	18	6.2	241	82.6	21	7.2	12	4.1	292	..	18	6.2	241	82.6	21	7.2	12	4.1
Good	38	13.0	3	16.7	18	7.4	16	76.2	1	8.3	48	16.4	3	16.7	27	11.2	17	81.0	1	8.3	75	25.7	1	5.5	55	22.8	18	85.7	1	8.3
Fair	117	40.0	6	33.3	103	42.8	5	23.8	3	25.0	95	32.7	5	27.8	83	34.4	4	19.0	3	25.0	71	24.2	5	27.8	61	25.3	3	14.3	2	16.7
Bad	97	33.1	8	44.5	85	35.3	..	..	4	33.3	90	30.5	8	44.5	79	32.8	..	..	3	25.0	55	18.8	10	55.5	40	16.6	..	..	5	41.7
Very bad	37	12.7	..	..	33	13.7	..	..	4	33.3	52	17.8	1	5.5	46	19.1	..	..	5	41.6	76	26.0	2	11.1	70	29.0	..	..	4	33.3
Not given	3	1.3	1	5.5	2	.8	..	..	..	..	7	2.4	1	5.5	6	2.6	..	..	..	..	15	5.2	..	..	15	6.2	..	..	..	..

NOTE: Building not noted on eight cards.

EXHIBIT 15.—BUILDINGS ACCORDING TO EXPECTORATION AND SCREENING

STORES

SCORE	EXPECTORATION										SCREENING									
	TOTAL		Residence		Store		Factory		Tenement		TOTAL		Residence		Store		Factory		Tenement	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
FRONT ROOM																				
Total	1,022	..	36	3.6	927	90.2	21	2.5	38	3.7	1,022	..	36	3.6	927	90.2	21	2.5	38	3.7
Good	591	57.8	27	75.0	533	57.5	14	66.7	17	44.8	326	31.2	3	8.3	314	33.9	1	4.8	8	21.0
Fair	5	.5	1	2.7	3	.3	..	..	1	2.6	168	16.5	1	2.8	166	17.9	1	4.8	..	..
Bad	52	5.1	2	5.5	44	4.7	..	..	6	15.6	10	1.0	..	..	3	.3	7	33.3	..	..
Very bad	354	34.7	6	16.6	334	36.0	1	4.7	13	34.3	473	46.9	26	72.2	417	45.0	..	..	30	79.0
Not given	20	2.0	..	..	13	1.4	6	28.7	1	2.6	45	4.3	6	16.7	27	2.8	12	57.1	..	..
WORK ROOM																				
Total	292	..	18	6.2	241	82.6	21	7.2	12	4.1	292	..	18	6.2	241	82.6	21	7.2	12	4.1
Good	76	26.0	..	..	58	24.0	14	66.7	4	33.3	22	7.5	..	..	11	4.6	11	52.5	..	..
Fair	1	.3	..	..	1	.4	..	..	..	..	12	4.1	..	..	7	2.9	5	23.8	..	..
Bad	3	1.1	..	..	2	.8	..	..	1	8.3	16	5.7	..	..	16	6.6	..	..	..	..
Very bad	24	8.2	1	5.5	18	7.5	5	23.8	..	..	33	11.3	..	..	26	10.8	4	19.0	3	25.0
Not given	188	64.3	17	94.5	162	67.2	2	9.5	7	58.3	209	71.5	18	100.0	181	75.1	1	4.8	9	75.0

EXHIBIT 16.—BUILDINGS ACCORDING TO GENERAL, SHOP, AND FOOD SCORES

STORES

SCORE	GENERAL SCORE											
	TOTAL		Residence		Store		Factory		Tenement		Not given	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Total	1,030	..	36	3.5	927	89.8	21	2.0	38	3.7	8	.8
1	..	..	..	..	..	..	..	..	..	..	..	..
2	..	..	..	..	..	..	..	..	..	..	..	..
3	6	.6	..	..	5	.5	..	..	1	2.6	..	..
4	34	3.3	2	5.6	30	3.2	..	..	2	5.3	..	..
5	86	8.3	3	8.3	77	8.3	..	..	6	15.8	..	..
6	134	13.0	3	8.3	125	13.5	1	4.8	5	13.2	..	..
7	213	20.7	13	36.1	181	19.5	1	4.8	17	44.7	1	12.5
8	251	24.3	10	27.8	225	24.3	5	23.8	7	18.4	4	50.0
9	245	23.8	5	13.9	229	24.7	10	47.6	..	..	1	12.5
10	61	5.9	..	..	55	5.9	4	19.0	..	..	2	25.0
Not given	..	..	..	..	..	..	..	..	..	..	..	..

SCORE	SHOP SCORE											
	TOTAL		Residence		Store		Factory		Tenement		Not given	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Total	1,030	..	36	3.5	927	89.8	21	2.0	38	3.7	8	.8
1	1	.1	..	..	1	.1	..	..	..	..	..	..
2	..	..	..	..	..	..	..	..	..	..	..	..
3	1	.1	..	..	1	.1	..	..	..	..	..	..
4	14	1.4	..	..	13	1.4	..	..	1	2.6	..	..
5	27	2.6	1	2.8	24	2.6	..	..	2	5.3	..	..
6	67	6.5	3	8.3	61	6.6	..	..	3	7.9	..	..
7	221	21.4	10	27.8	197	21.2	2	9.5	11	28.9	1	12.5
8	310	30.1	14	38.9	274	29.6	3	14.3	16	42.1	3	37.5
9	255	24.8	8	22.2	232	25.0	8	38.1	5	13.2	2	25.0
10	132	12.8	..	..	124	13.4	8	38.1	..	..	..	..
Not given	2	.2	..	..	..	..	..	..	..	..	2	25.0

SCORE	FOOD SCORE											
	TOTAL		Residence		Store		Factory		Tenement		Not given	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Total	1,030	..	36	3.5	927	89.8	21	2.0	38	3.7	8	.8
1	79	7.7	5	13.9	67	7.2	..	..	7	18.4	..	..
2	12	1.2	..	..	11	1.2	..	..	1	2.6	..	..
3	65	6.3	2	5.6	58	6.3	1	4.8	3	7.9	1	12.5
4	76	7.4	1	2.8	69	7.4	..	..	6	15.8	..	..
5	86	8.3	3	8.3	77	8.3	1	4.8	4	10.5	1	12.5
6	69	6.7	1	2.8	65	7.0	..	..	3	7.9	..	..
7	113	10.9	6	16.7	94	10.1	4	19.0	8	21.1	1	12.5
8	141	13.7	6	16.7	130	14.0	2	9.5	3	7.9	..	..
9	115	11.2	3	8.3	109	11.8	2	9.5	1	2.6	..	..
10	266	25.8	9	25.0	241	26.0	11	52.4	2	5.3	3	37.5
Not given	8	.8	..	..	6	.6	..	..	..	..	2	25.0

EXHIBIT 17.—NATIONALITY ACCORDING TO KINDS OF BUSINESS
STORES

KIND OF BUSINESS	TOTAL		HEBREW		AFRO-AMERICAN		AMERICAN		ITALIAN		GERMAN		IRISH		MISCELLANEOUS	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Total	1030	..	442	42.8	20	1.9	158	15.4	215	20.9	84	8.2	27	2.6	84	8.2
Grocery	398	38.6	186	42.1	11	55.0	35	22.2	101	47.0	20	23.8	15	55.5	30	35.7
Bakery	112	10.9	35	7.9	..	..	17	10.8	23	10.7	25	29.8	..	..	12	14.3
Meat	182	17.7	87	19.7	1	5.0	24	15.2	30	14.0	18	21.4	5	18.5	17	20.2
Fish	30	2.9	9	2.0	..	..	12	7.6	6	2.8	2	2.4	1	3.7	..	..
Creamery	64	6.2	31	7.0	..	..	17	10.8	3	1.4	6	7.1	2	7.4	5	6.0
Ice cream	13	1.3	6	1.4	..	..	5	3.2	1	.5	..	..	..	..	1	1.2
Provisions	100	9.7	39	8.8	3	15.0	14	8.9	30	14.0	4	4.8	1	3.7	9	10.7
Confectionery	96	9.3	39	8.8	2	10.0	22	13.9	17	7.9	7	8.3	2	7.4	7	8.3
Restaurant	35	3.4	10	2.3	3	15.0	12	7.6	4	1.8	2	2.4	1	3.7	3	3.6

EXHIBIT 18.—TIME IN UNITED STATES ACCORDING TO KINDS OF BUSINESS
STORES

TIME IN UNITED STATES	TOTAL		GROCERY		BAKERY		MEAT		FISH		CREAMERY		ICE CREAM		PROVISIONS		CONFECTIONERY		RESTAURANT	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Total	1030	..	398	38.6	112	10.9	182	17.6	30	2.9	64	6.2	13	1.3	100	9.7	96	9.3	35	3.4
4 mo. or less	1	0.1	1	.2	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
4 mo.–1 year	1	0.1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	1.0	..	..
1–2 years	4	0.4	1	.2	2	1.8	1	.5	..	..	..	..	..	..	..	..	..	..	..	..
2–5 years	38	3.7	15	3.7	4	3.6	6	3.2	1	3.3	1	1.5	..	..	3	3.0	5	5.2	3	8.6
5–10 years	124	12.0	53	13.3	15	13.4	23	12.6	3	10.0	6	9.4	1	7.7	5	5.0	14	14.6	4	11.4
10–15 years	192	18.6	79	19.8	17	15.2	39	21.5	7	23.3	11	17.2	2	15.4	16	16.0	14	14.6	7	20.0
15–20 years	92	8.9	31	7.8	11	9.8	19	10.5	1	3.3	9	14.1	..	..	13	13.0	6	6.3	2	5.7
20–25 years	142	13.8	61	15.7	16	14.3	20	11.0	2	6.7	8	12.5	3	23.1	20	20.0	12	12.5	..	..
25 years–	192	18.6	83	20.9	25	22.3	33	18.1	3	10.0	8	12.5	2	15.4	19	19.0	17	17.7	2	5.7
Born in U. S.	244	23.7	74	18.6	22	19.6	41	22.6	13	43.3	21	32.8	5	38.5	24	24.0	27	28.2	17	48.6

EXHIBIT 19.—GENERAL SCORE ACCORDING TO NATIONALITIES

STORES

Score	Total		Hebrew		Afro-American		American		Italian		German		Irish		Miscellaneous	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Total..........	1,030	..	442	42.8	20	1.9	158	15.4	215	20.9	84	8.2	27	2.6	84	8.2
1.............	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
2.............	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
3.............	6	.6	3	.7	..	..	1	.6	1	.5	1	1.2	..	..	..	..
4.............	34	3.3	17	3.8	3	15.0	3	1.9	9	4.2	..	..	1	3.7	1	1.2
5.............	86	8.3	49	11.1	3	15.0	1	.6	23	10.7	4	4.7	..	..	6	7.1
6.............	134	13.0	74	16.7	4	20.0	5	3.2	37	17.2	5	6.0	1	3.7	8	9.5
7.............	213	20.7	118	26.7	1	5.0	24	15.2	26	12.1	12	14.3	2	7.4	30	35.7
8.............	251	24.3	97	21.9	3	15.0	39	24.7	46	21.4	31	36.9	6	22.2	29	34.6
9.............	245	23.8	75	17.0	5	25.0	57	36.1	61	28.4	26	31.0	13	48.2	8	9.5
10.............	61	5.9	9	2.2	1	5.0	28	17.7	12	5.6	5	6.0	4	14.8	2	2.4

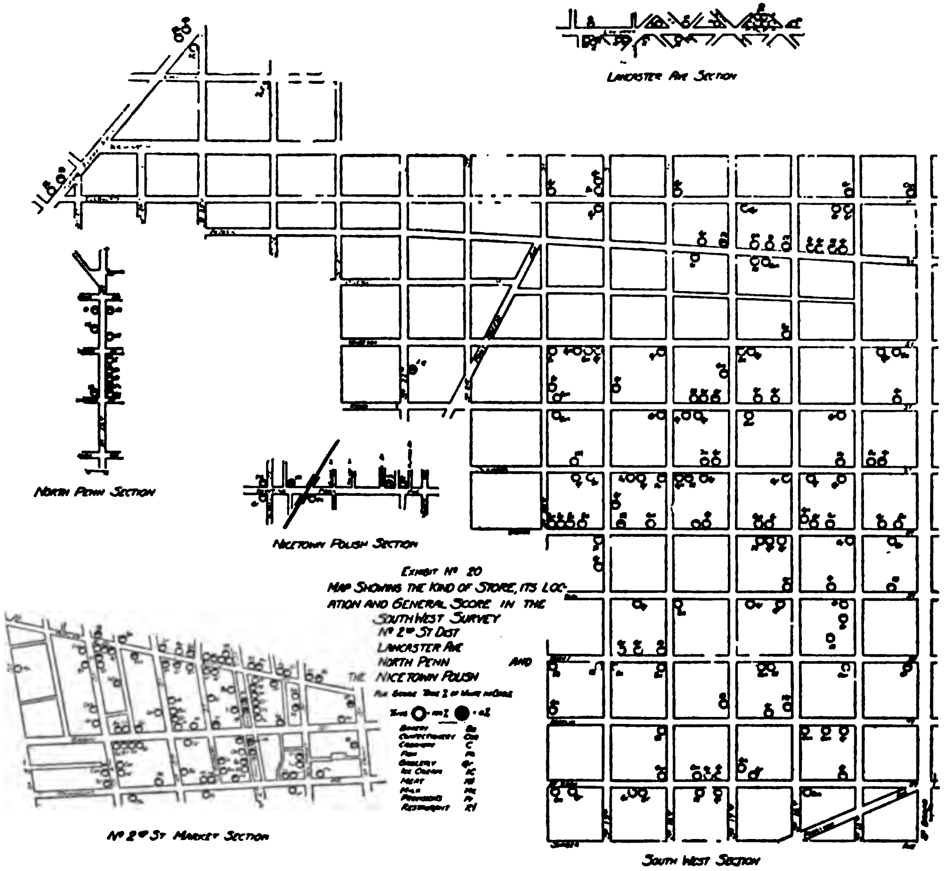


EXHIBIT No 20
MAP SHOWING THE KIND OF STORE, ITS LOCATION AND GENERAL SCORE IN THE
SOUTH WEST SURVEY
No 2nd ST DIST
LANCASTER AVE
NORTH PENN AND
THE NICETOWN POLISH

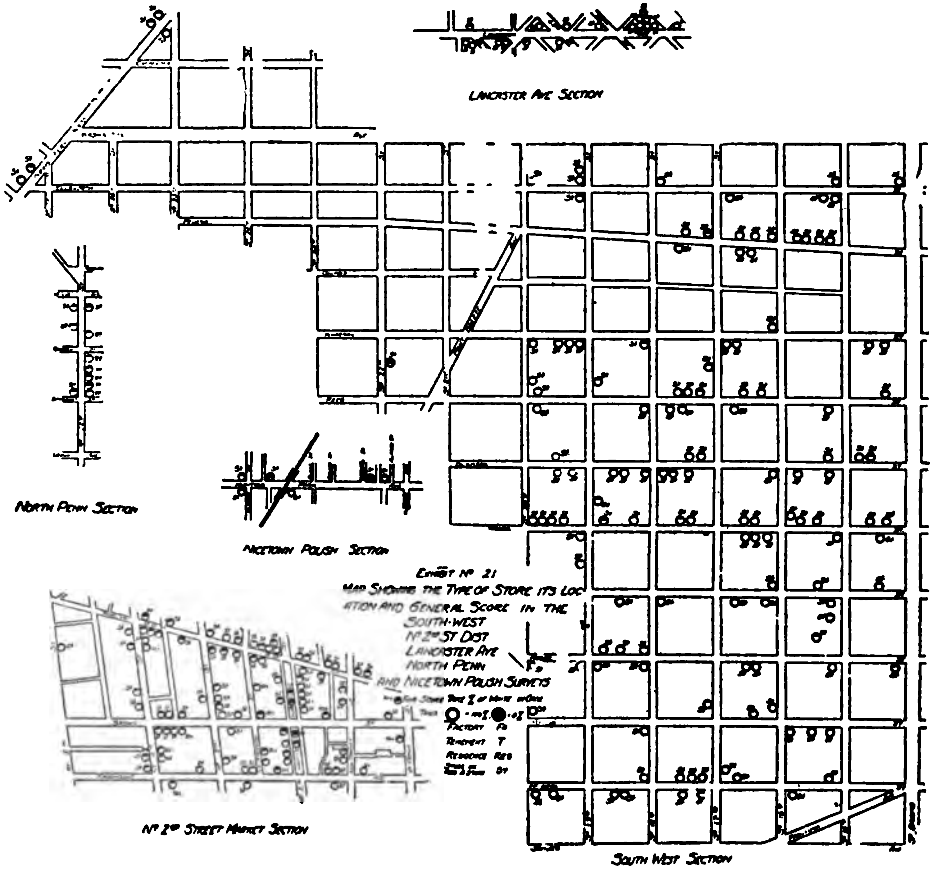
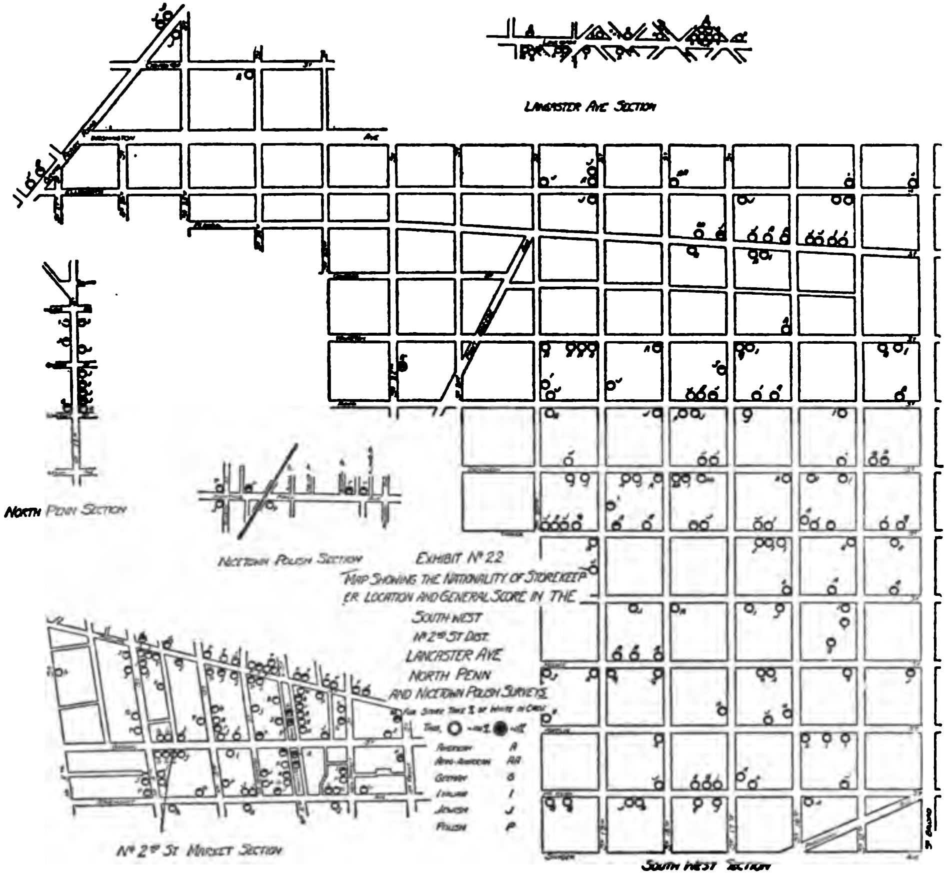


Exhibit No 21

Map Showing the Type of Store its Location and General Score in the South-West, No 2nd St Dist, Lancaster Ave, North Penn and Nicetown Polish Surveys



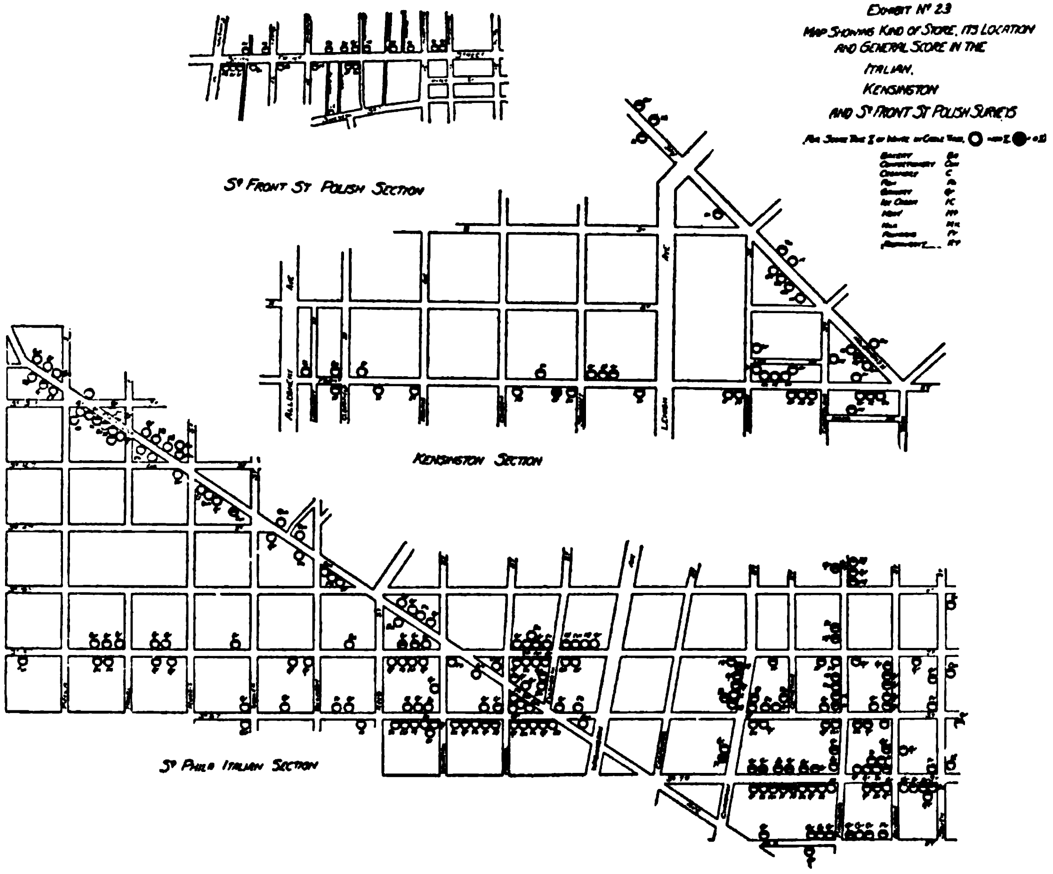


Exhibit No 23

Map Showing Kind of Store, its Location and General Score in the Italian, Kensington and St Front St Polish Surveys

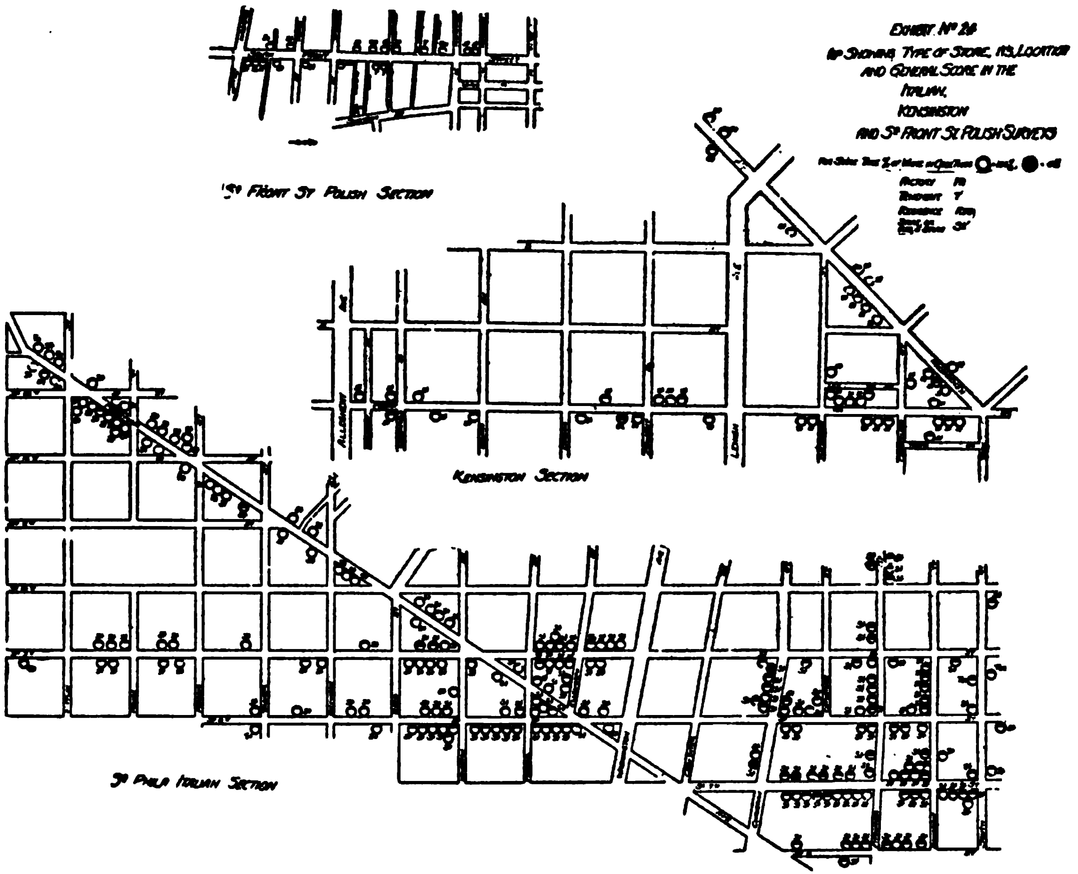


Exhibit No 28
Map Showing Type of Store, Its Location
and General Score in the
Italian,
Kensington
and So Front St Polish Surveys
Tenement T
So Front St Polish Section
Kensington Section
So Phila Italian Section
Allegheny
Lehigh

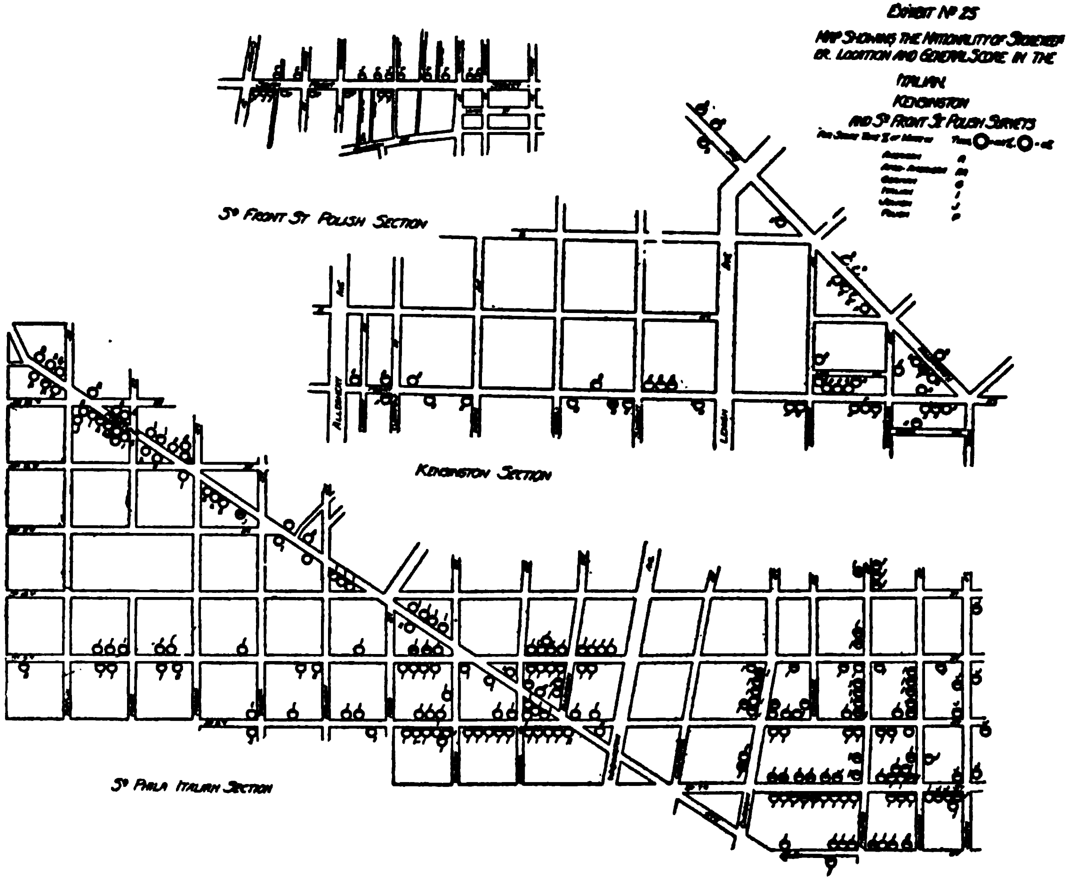


EXHIBIT Nº 25
MAP SHOWING THE NATIONALITY OF STOREKEEPER. LOCATION AND GENERAL SCORE IN THE
ITALIAN
KENSINGTON
AND SO FRONT ST POLISH SURVEYS

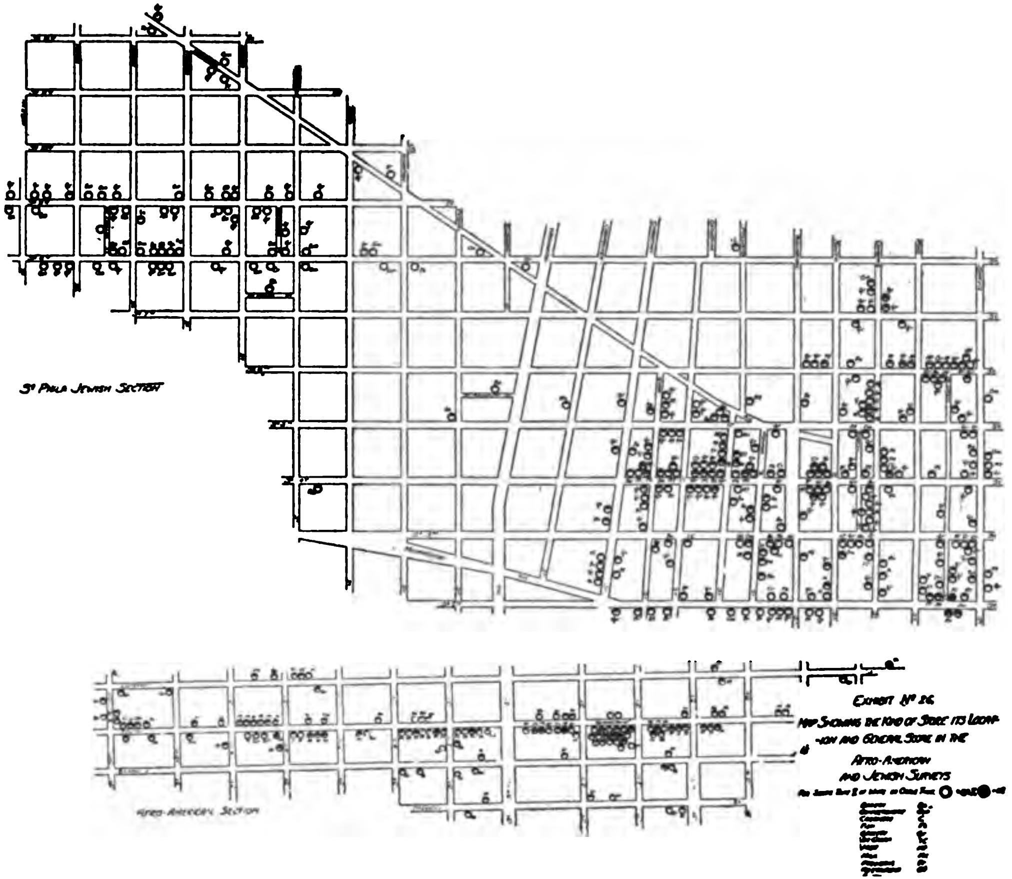
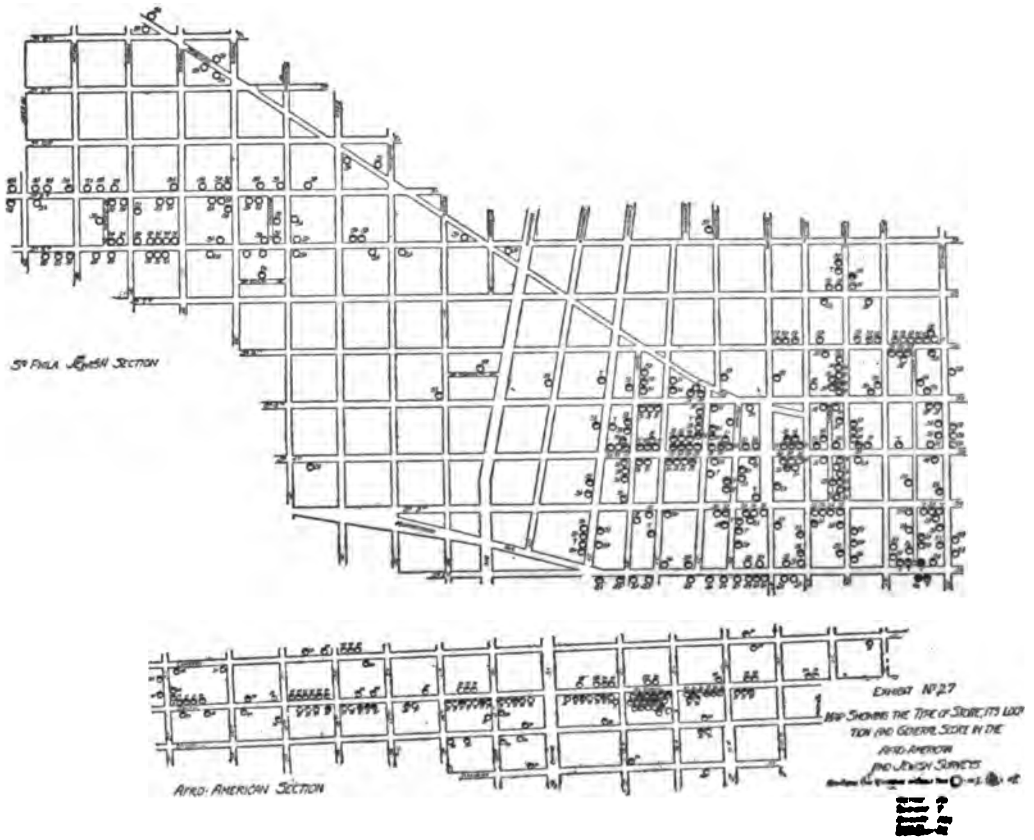


Exhibit No 26
Map Showing the Kind of Store its Location and General Score in the Afro-American and Jewish Surveys


5th Phila. Jewish Section
Afro-American Section
Exhibit No. 27
Map Showing the Type of Store, its Location and General Score in the Afro-American and Jewish Surveys

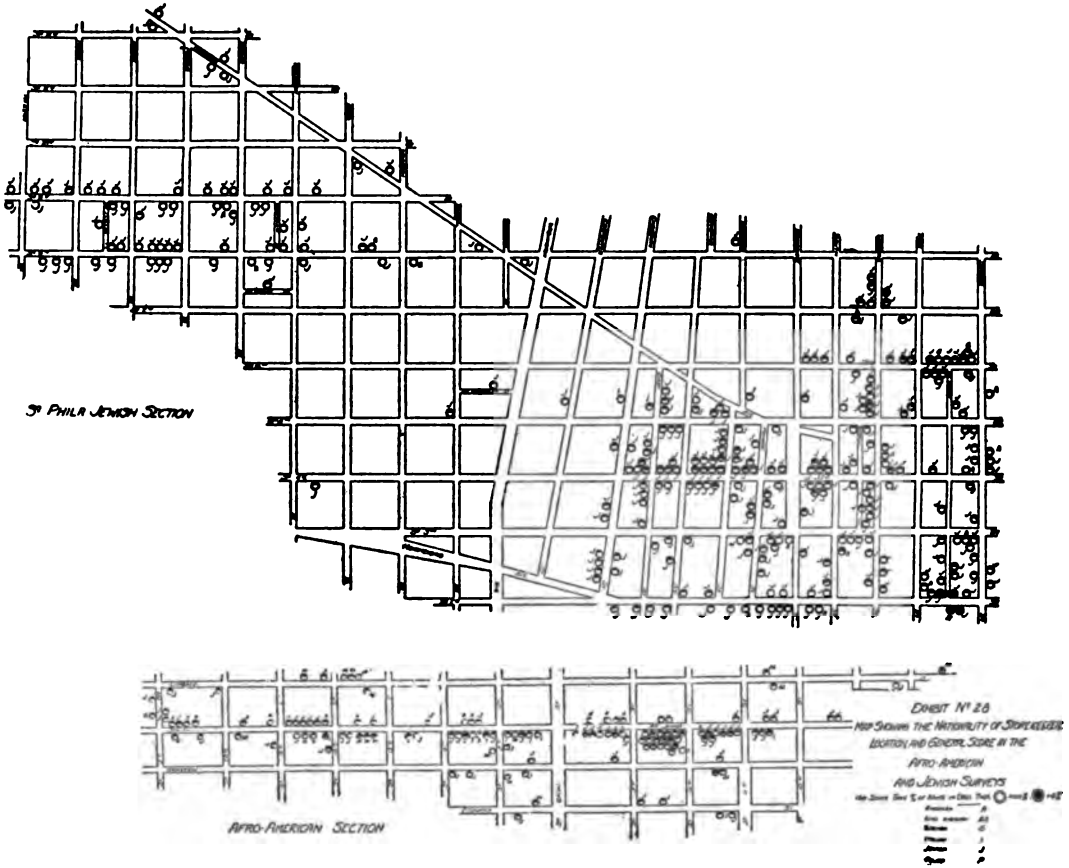

5th Phila Jewish Section
Afro-American Section
Exhibit No 28
Map Showing the Nationality of Storekeepers
Location and General Score in the
Afro-American
and Jewish Surveys

EXHIBIT 29.—NATIONALITY ACCORDING TO GENERAL SCORE

PUSH-CARTS AND STANDS

GENERAL SCORE	TOTAL		HEBREW		AFRO-AMERICAN		AMERICAN		ITALIAN		GERMAN		IRISH		MISCELLANEOUS		NOT GIVEN	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Total	194	..	41	21.1	4	2.1	31	16.0	64	33.0	4	2.1	2	1.0	45	23.2	3	1.6
1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
2	1	.5	..	..	..	..	..	..	1	1.6	..	..	..	..	..	..	..	..
3	6	3.1	2	4.9	..	..	..	..	4	6.6	..	..	..	..	..	..	..	..
4	19	9.8	6	14.6	2	50.0	2	6.5	7	11.5	..	..	..	..	1	2.2	1	33.3
5	36	18.5	18	43.9	1	25.0	5	16.1	6	9.8	..	..	1	50.0	4	8.9	1	33.3
6	44	22.7	11	26.8	..	..	8	25.8	8	13.1	1	25.0	1	50.0	15	33.3	..	..
7	40	20.6	2	4.9	..	..	8	25.8	7	11.5	3	75.0	..	..	19	42.2	1	33.3
8	27	13.9	2	4.9	1	25.0	5	16.1	14	22.9	..	..	..	.	5	11.1	..	..
9	19	9.6	..	..	..	..	3	9.7	15	24.5	..	..	..	..	1	2.2	..	..
10	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Not given	2	1.0	..	..	..	..	..	..	2	3.3	..	..	..	..	..	..	..	..

EXHIBIT 30.—NATIONALITY ACCORDING TO FOOD SCORE

PUSH-CARTS AND STANDS

FOOD SCORE	TOTAL		HEBREW		AFRO-AMERICAN		AMERICAN		ITALIAN		GERMAN		IRISH		MISCELLANEOUS		NOT GIVEN	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Total	194	..	41	21.1	4	2.0	31	16.0	64	33.0	4	2.0	2	1.0	45	23.2	3	1.6
1	2	1.0	1	2.4	..	..	..	..	1	1.6	..	..	..	..	..	..	..	..
2	2	1.0	1	2.4	..	..	..	..	1	1.6	..	..	..	..	..	..	..	..
3	10	5.2	3	7.3	..	..	..	..	7	10.9	..	..	..	..	..	..	..	..
4	18	9.3	4	9.7	3	75.0	1	3.2	8	12.5	..	..	..	..	2	4.4	..	..
5	26	13.4	15	36.6	..	..	5	16.1	2	3.2	..	..	..	..	2	4.4	2	66.7
6	37	19.1	11	26.9	..	..	6	19.3	4	6.3	1	25.0	..	..	15	33.3	..	..
7	42	21.6	2	4.9	..	..	10	32.2	11	17.2	2	50.0	1	50.0	15	33.3	1	33.3
8	31	15.9	3	7.3	1	25.0	5	16.1	11	17.2	1	25.0	..	..	10	22.2	..	..
9	20	10.4	..	..	..	..	2	6.4	17	26.6	..	..	..	..	1	2.2	..	..
10	4	2.0	..	..	..	..	2	6.4	2	3.2	..	..	..	..	..	..	..	..
Not given	2	1.0	1	2.4	..	..	..	..	..	..	..	..	1	50.0	..	..	..	..

EXHIBIT 31.—TIME IN UNITED STATES ACCORDING TO GENERAL SCORE

PUSH-CARTS AND STANDS

Score	Total		4 Mos.		4 Mos.–1 Yr.		1–2 Yrs.		2–5 Yrs.		5–10 Yrs.		10–15 Yrs.		15–20 Yrs.		20–25 Yrs.		25 Yrs.		Born in U. S.		Not Given	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Total......	194	..	28	14.4	1	.5	5	2.6	6	3.1	12	6.2	35	18.1	33	17.0	14	7.2	18	9.3	26	13.4	16	8.3
1........	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
2........	1	.5	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	3.8	..	..
3........	6	3.1	1	3.6	..	..	..	..	..	..	..	..	1	2.9	1	3.0	..	..	1	5.6	2	7.7	..	..
4........	19	9.8	5	17.9	..	..	..	..	..	..	..	..	1	2.9	2	6.0	3	21.4	3	16.7	3	11.5	2	12.5
5........	36	18.5	6	21.4	..	..	..	..	3	50.0	3	25.0	6	17.1	7	21.2	3	21.4	2	11.1	4	15.2	2	12.5
6........	44	22.7	3	10.7	1	100.0	2	40.0	1	16.7	4	33.3	7	20.0	9	27.4	3	21.4	3	16.7	6	23.1	5	31.2
7........	40	20.6	8	28.6	..	..	1	20.0	1	16.7	1	8.3	6	17.1	6	18.2	1	7.2	7	38.9	7	26.9	2	12.5
8........	27	13.9	3	10.7	..	..	2	40.0	1	16.7	2	16.7	7	20.0	5	16.7	3	21.4	..	..	..	..	4	25.0
9........	19	9.8	2	7.2	..	..	..	..	..	..	2	16.7	7	20.0	2	6.0	1	7.2	1	5.6	3	11.4	1	6.3
10........	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Not given..	2	1.0	..	..	..	..	..	..	..	..	..	..	..	..	1	3.0	..	..	1	5.6	..	..	..	..

EXHIBIT 32.—KINDS OF FOOD HANDLED ACCORDING TO FOOD SCORE

PUSH-CARTS AND STANDS

Score	Total		Milk		Poultry		Meat		Fish		Vegetables		Butter and Cheese		Confectionery		Bread		Pastry		Dried Fruit		Fruit		Eggs		Ice Cream	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Total...........	289	..	2	0.7	4	1.4	8	2.8	18	6.2	105	36.3	3	1.1	6	2.1	16	5.5	3	1.1	5	1.8	117	40.2	1	0.3	1	0.3
1..............	3	1.0	..	..	..	..	..	..	1	5.5	1	1.0	..	..	..	..	..	..	..	..	..	..	1	.9	..	..	..	..
2..............	3	1.0	..	..	..	..	..	..	..	..	2	1.9	..	..	..	..	..	..	..	..	1	20.0	..	..	..	..	..	..
3..............	17	5.9	1	50.0	2	50.0	..	..	1	5.5	5	4.8	1	33.3	1	16.7	1	6.3	1	33.3	..	..	3	2.6	1	100.0	..	..
4..............	35	12.1	..	..	..	..	..	..	5	27.8	12	11.4	..	..	..	..	3	18.8	..	..	3	60.0	12	10.2	..	..	..	..
5..............	41	14.2	..	..	..	..	1	12.5	5	27.8	18	17.1	..	..	..	..	1	6.3	..	..	..	..	16	13.7	..	..	..	..
6..............	54	18.7	..	..	1	25.0	3	37.5	1	5.5	19	18.1	1	33.3	1	16.7	4	25.0	1	33.3	1	20.0	22	18.8	..	..	..	..
7..............	61	21.1	..	..	1	25.0	3	37.5	1	5.5	25	23.8	1	33.3	2	33.3	4	25.0	1	33.3	..	..	23	19.7	..	..	..	..
8..............	45	15.6	..	..	..	..	1	12.5	..	..	16	15.2	..	..	1	16.7	2	12.5	..	..	..	..	25	21.4	..	..	..	..
9..............	26	9.0	..	..	..	..	..	..	3	16.7	7	6.7	..	..	1	16.7	1	6.3	..	..	..	..	14	12.0	..	..	..	..
10..............	4	1.4	1	50.0	..	..	..	..	1	5.5	..	..	..	..	..	..	..	..	..	..	..	..	1	.9	..	..	1	100.0

EXHIBIT 33.—KIND OF FOOD AND NUMBER HANDLED ACCORDING TO FOOD SCORE

PUSH-CARTS AND STANDS

SCORE	GRAND TOTAL		TOTAL—ONE KIND OF FOOD		MILK ONLY		POULTRY ONLY		MEAT ONLY		FISH ONLY		VEGETABLES ONLY		BUTTER AND CHEESE ONLY		CONFECTIONERY ONLY		BREAD ONLY		PASTRY ONLY		DRIED FRUIT ONLY		FRUIT ONLY		EGGS ONLY		ICE CREAM ONLY		TWO KINDS OF FOOD		THREE KINDS OF FOOD		MORE THAN THREE KINDS OF FOOD	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Total....	192*	..	102	53.3	1	0.5	2	1.0	8	4.2	11	5.7	22	11.5	2	1.0	3	1.5	11	5.7	..	..	..	..	40	20.9	1	0.5	1	0.5	83	43.2	6	3.0	1	0.5
1.......	2	1.0	1	1.0	..	..	..	..	..	..	1	9.1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	1.2	..	..	..	..
2.......	2	1.0	1	1.0	..	..	..	..	..	..	..	..	1	4.5	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	1.2	..	..	..	..
3.......	10	5.2	5	5.0	..	..	1	50.0	..	..	1	9.1	1	4.5	1	50.0	..	..	..	..	..	..	..	..	..	..	1	100.0	..	..	3	3.6	2	33.3	..	..
4.......	18	9.4	5	5.0	..	..	..	..	..	..	1	9.1	..	..	..	..	..	..	2	18.2	..	..	..	..	2	5.0	..	..	..	..	10	12.0	2	33.3	1	100.0
5.......	26	13.5	11	10.7	..	..	..	..	1	12.5	3	27.3	4	18.2	..	..	..	..	1	9.1	..	..	..	..	2	5.0	..	..	..	..	14	16.9	1	16.7	..	..
6.......	37	19.3	21	20.6	..	..	1	50.0	3	37.5	1	9.1	3	13.7	1	50.0	1	33.3	3	27.3	..	..	..	..	8	20.0	..	..	..	..	15	18.1	1	16.7	..	..
7.......	42	21.8	23	22.6	..	..	..	..	3	37.5	1	9.1	8	36.4	..	..	1	33.3	3	27.3	..	..	..	..	7	17.5	..	..	..	..	19	22.9	..	..	..	..
8.......	31	16.1	17	16.6	..	..	..	..	1	12.5	..	..	3	13.7	..	..	..	..	2	18.2	..	..	..	..	11	27.5	..	..	..	..	14	16.9	..	..	..	..
9.......	20	10.4	14	13.6	..	..	..	..	..	..	2	18.2	2	9.1	..	..	1	33.3	..	..	..	..	..	..	9	22.5	..	..	..	..	6	7.2	..	..	..	..
10.......	4	2.1	4	4.0	1	100.0	..	..	..	..	1	9.1	..	..	..	..	..	..	..	..	..	..	..	..	1	2.5	..	..	1	100.0	..	..	..	..	..	..

* NOTE: Total number of investigations 194, 2 push-cart stables, for which there would be no food score.

EXHIBIT 34.—CARTS HANDLING MORE THAN ONE KIND OF FOOD ACCORDING TO FOOD SCORE

PUSH-CARTS AND STANDS

FOOD SCORE	GRAND TOTAL		TWO KINDS OF FOOD																						THREE KINDS OF FOOD												FOUR KINDS OF FOOD	
			Total		Fruit and Vegetables		Vegetables and Dried Fruit		Vegetables and Bread		Vegetables and Fish		Vegetables and Poultry		Poultry and Butter		Fish and Bread		Confectionery and Pastry		Confectionery and Fruit		Dried Fruit and Fruit		Total		Vegetables, Fish and Fruit		Vegetables, Dried Fruit and Fruit		Vegetables, Bread and Fruit		Vegetables, Pastry and Fruit		Milk, Confectionery and Pastry		Vegetables, Bread, Dried Fruit and Fruit	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Total..........	90	..	83	92.2	69	83.2	2	2.4	2	2.4	4	4.8	1	1.2	1	1.2	1	1.2	1	1.2	1	1.2	1	1.2	6	66.7	2	33.3	1	16.7	1	16.7	1	16.7	1	16.7	1	1.1
1............	1	1.1	1	1.2	1	1.4	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
2............	1	1.1	1	1.2	..	..	1	50.0	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
3............	5	5.6	3	3.6	2	2.9	..	..	..	..	..	..	1	100.0	..	..	..	..	..	..	..	..	..	..	2	33.3	..	..	..	..	1	100.0	..	..	1	100.0	..	..
4............	13	14.5	10	12.0	6	8.7	..	..	..	..	3	75.0	..	..	..	..	..	..	..	..	..	..	1	100.0	2	33.3	1	50.0	1	100.0	..	..	..	..	..	..	1	100.0
5............	15	16.7	14	16.9	13	18.8	..	..	..	..	1	25.0	..	..	..	..	..	..	..	..	..	..	..	..	1	16.7	1	50.0	..	..	..	..	..	..	..	..	..	..
6............	16	17.8	15	18.1	13	18.8	1	50.0	1	50.0	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	16.7	..	..	..	..	..	..	1	100.0	..	..	..	..
7............	19	21.1	19	22.9	16	23.2	..	..	1	50.0	..	..	..	..	1	100.0	..	..	1	100.0	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
8............	14	15.6	14	16.9	13	18.8	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	100.0	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
9............	6	6.7	6	7.2	5	7.3	..	..	..	..	..	..	..	..	..	..	1	100.0	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
10............	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..

EXHIBIT 35.—FOODS ACCORDING TO EXPOSURE TO DUST AND HANDLING

Push-Carts and Stands

Score	Total		Milk		Poultry		Meat		Fish		Vegetables		Butter and Cheese		Confectionery		Bread		Pastry		Dried Fruit		Fruit	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Dust																								
Total	287	..	2	0.7	4	1.4	8	2.8	18	6.2	105	36.6	3	1.1	6	2.1	16	5.6	3	1.1	5	1.8	117	40.5
Good	12	4.2	1	50.0	1	25.0	1	12.5	2	11.1	1	1.0	..	..	2	33.3	..	..	1	33.3	..	..	3	2.6
Fair	55	19.2	..	..	1	25.0	1	12.5	2	11.1	18	17.1	1	33.3	2	33.3	1	6.2	..	..	..	..	29	24.8
Bad	66	23.0	..	..	..	..	3	37.5	1	5.5	27	25.7	1	33.3	..	..	3	18.7	..	..	..	..	31	26.5
Very bad	150	52.3	1	50.0	2	50.0	3	37.5	13	72.3	57	54.3	1	33.3	2	33.3	11	68.7	2	66.7	5	100.0	53	45.3
Not given	4	1.4	..	..	..	..	..	..	..	..	2	1.9	..	..	..	..	1	6.2	..	..	..	..	1	0.9
Handling																								
Total	287	..	2	0.7	4	1.4	8	2.8	18	6.2	105	36.6	3	1.1	6	2.1	16	5.6	3	1.1	5	1.8	117	40.5
Good	12	4.2	1	50.0	..	..	1	12.5	2	11.1	1	1.0	..	..	1	16.7	1	6.2	1	33.3	..	..	4	3.4
Fair	128	44.6	..	..	1	25.0	5	62.5	2	11.1	49	46.7	1	33.3	3	50.0	6	37.5	..	..	..	..	61	52.1
Bad	32	11.2	..	..	..	..	..	..	2	11.1	13	12.4	2	66.7	..	..	3	18.7	..	..	..	..	12	10.3
Very bad	110	38.4	1	50.0	3	75.0	2	25.0	12	66.7	40	38.1	..	..	2	33.3	5	31.2	2	66.7	5	100.0	38	32.4
Not given	5	1.7	..	..	..	..	..	..	..	..	2	1.9	..	..	..	..	1	6.2	..	..	..	..	2	1.7

NOTE: 2 push-cart stables. 1 push-cart handles eggs only. 1 push-cart handles ice cream only.

EXHIBIT 36.—NATIONALITY ACCORDING TO SCORES FOR EXPOSURE TO DUST AND HANDLING

Push-Carts and Stands

Nationality	Dust												Handling											
	Total		Good		Fair		Bad		Very Bad		Not Given		Total		Good		Fair		Bad		Very Bad		Not Given	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Total	190	..	7	3.7	43	22.6	37	19.5	101	53.2	2	1.0	190	..	8	4.2	90	47.3	22	11.6	66	34.7	4	2.1
Hebrew	40	21.0	..	..	2	4.7	3	8.1	35	34.6	..	..	40	21.0	..	..	10	11.1	6	27.3	24	36.4	..	..
Afro-American	4	2.1	..	..	1	2.3	..	..	3	3.0	..	..	4	2.1	..	..	1	1.1	..	..	3	4.5	..	..
American	31	16.3	4	57.2	7	16.3	11	29.7	8	7.9	1	50.0	31	16.3	3	37.5	20	22.2	2	9.1	6	9.1	..	..
Italian	62	32.6	2	28.6	25	58.2	2	5.4	32	31.7	1	50.0	62	32.6	1	12.5	33	36.7	5	22.7	22	33.3	1	25.0
German	4	2.1	..	..	..	..	..	..	4	4.0	..	..	4	2.1	3	37.5	1	1.1	..	..	..	..	..	..
Irish	1	0.5	..	..	..	..	1	2.7	..	..	..	..	1	0.5	..	..	..	..	1	4.5	..	..	..	..
Miscellaneous	45	23.6	1	14.3	8	18.6	19	51.4	17	16.8	..	..	45	23.6	1	12.5	24	26.7	8	36.3	9	13.6	3	75.0
Not given	3	1.6	..	..	..	..	1	2.7	2	2.0	..	..	3	1.6	..	..	1	1.1	..	..	2	3.0	..	..

NOTE: 2 push-cart stables, 1 conducted by an Irish and 1 by a Hebrew proprietor.
1 push-cart handling eggs and 1 ice cream, conducted by Italians.

EXHIBIT 37.—FOODS ACCORDING TO EXPOSURE TO FLIES AND ANIMALS

PUSH-CARTS AND STANDS

SCORE	TOTAL		MILK		POULTRY		MEAT		FISH		VEGETABLES		BUTTER AND CHEESE		CONFECTIONERY		BREAD		PASTRY		DRIED FRUIT		FRUIT	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
FLIES																								
Total	287	..	2	0.7	4	1.4	8	2.8	18	6.2	105	36.6	3	1.1	6	2.1	16	5.6	3	1.1	5	1.8	117	40.5
Good	38	13.2	1	50.0	1	25.0	1	12.5	3	16.7	13	12.4	..	..	2	33.3	3	18.7	2	66.7	..	..	12	10.3
Fair	72	25.1	..	..	..	..	..	..	2	11.1	30	28.6	2	66.7	1	16.7	1	6.2	..	..	..	..	36	30.8
Bad	43	15.0	..	..	..	..	2	25.0	2	11.1	16	15.2	..	..	1	16.7	3	18.7	..	..	..	..	19	16.2
Very bad	127	44.3	1	50.0	3	75.0	4	50.0	11	61.1	44	41.8	1	33.3	2	33.3	8	50.0	1	33.3	5	100.0	47	40.2
Not given	7	2.4	..	..	..	..	1	17.5	..	..	2	1.9	..	..	..	..	1	6.2	..	..	..	..	3	3.4
ANIMALS																								
Total	287	..	2	0.7	4	1.4	8	2.8	18	6.2	105	36.6	3	1.1	6	2.1	16	5.6	3	1.1	5	1.8	117	40.5
Good	182	63.4	1	50.0	2	50.0	7	87.5	8	44.5	68	64.7	2	66.7	5	83.3	9	56.3	1	33.3	1	20.0	78	66.6
Fair	8	2.8	..	..	..	..	..	..	1	5.5	1	1.0	..	..	..	..	1	6.2	..	..	..	..	5	4.3
Bad	3	1.1	..	..	..	..	..	..	..	..	1	1.0	1	33.3	..	..	..	..	..	..	..	..	1	0.9
Very bad	75	26.1	1	50.0	2	50.0	1	12.5	8	44.5	27	25.7	..	..	1	16.7	5	31.2	2	66.7	4	80.0	24	20.5
Not given	19	6.6	..	..	..	..	..	..	1	5.5	8	7.6	..	..	..	..	1	6.2	..	..	..	..	9	7.7

NOTE: 2 push-cart stables. 1 push-cart handles eggs only. 1 push-cart handles ice cream only.

EXHIBIT 38.—NATIONALITY ACCORDING TO SCORES FOR EXPOSURE TO FLIES AND ANIMALS

PUSH-CARTS AND STANDS

NATIONALITY	TOTAL		FLIES										TOTAL		ANIMALS									
			Good		Fair		Bad		Very Bad		Not Given				Good		Fair		Bad		Very Bad		Not Given	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Total	190	..	23	12.1	42	22.1	39	20.5	80	42.1	6	3.2	190	..	131	69.0	5	2.6	2	1.0	40	21.0	12	6.4
Hebrew	40	21.0	1	4.3	2	4.8	4	10.3	31	38.7	2	33.3	40	21.0	16	12.2	2	40.0	2	100.0	16	40.0	4	33.3
Afro-American	4	2.1	..	..	1	2.4	..	..	3	3.7	..	..	4	2.1	1	0.8	..	..	..	..	3	7.5	..	..
American	31	16.3	9	39.1	4	9.5	9	23.1	9	11.2	..	..	31	16.3	25	19.1	..	..	..	..	4	10.0	2	16.7
Italian	62	32.6	12	52.2	24	57.2	2	5.1	22	27.5	2	33.3	62	32.6	42	32.0	1	20.0	..	..	16	40.0	3	25.0
German	4	2.1	..	..	..	..	1	2.6	3	3.7	..	..	4	2.1	4	3.1	..	..	..	..	..	..	..	..
Irish	1	0.5	..	..	1	2.4	..	..	..	..	..	..	1	0.5	1	0.8	..	..	..	..	..	..	..	..
Miscellaneous	45	23.6	1	4.3	9	21.4	23	59.0	11	13.8	1	16.7	45	23.6	39	29.8	2	40.0	..	..	1	2.5	3	25.0
Not given	3	1.6	..	..	1	2.4	..	..	1	1.2	1	16.7	3	1.6	3	2.3	..	..	..	..	..	..	..	..

NOTE: 2 push-cart stables, 1 conducted by an Irish and 1 by a Hebrew proprietor.
1 push-cart handling eggs and 1 ice cream, conducted by Italians.

EXHIBIT 39.—FOODS ACCORDING TO CONDITION OF PRESERVATION

PUSH-CARTS AND STANDS

SCORE	TOTAL		MILK		POULTRY		MEAT		FISH		VEGETABLES		BUTTER AND CHEESE		CONFECTIONERY		BREAD		PASTRY		DRIED FRUIT		FRUIT	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Total	287	..	2	0.7	4	1.4	8	2.8	18	6.2	105	36.6	3	1.1	6	2.1	16	5.6	3	1.1	5	1.8	117	40.5
Good	108	37.7	1	50.0	1	25.0	..	..	6	33.3	40	38.1	1	33.3	3	50.0	5	31.2	1	33.3	2	40.0	48	41.0
Fair	131	45.7	..	..	2	50.0	6	75.0	9	50.0	49	46.7	..	..	1	16.7	9	56.3	1	33.3	3	60.0	51	43.6
Bad	34	11.8	..	..	..	..	1	12.5	1	5.5	13	12.4	1	33.3	1	16.7	2	12.5	1	33.3	..	..	14	12.0
Very bad	6	2.1	1	50.0	..	..	1	12.5	1	5.5	1	1.0	..	..	..	..	..	..	..	..	..	..	2	1.7
Not given	8	2.8	..	..	1	25.0	..	..	1	5.5	2	1.9	1	33.3	1	16.7	..	..	..	..	..	..	2	1.7

NOTE: 2 push-cart stables. 1 push-cart handles eggs only. 1 push-cart handles ice cream only.

EXHIBIT 40.—NATIONALITY ACCORDING TO SCORE FOR CONDITION OF PRESERVATION

PUSH-CARTS AND STANDS

NATIONALITY	TOTAL		GOOD		FAIR		BAD		VERY BAD		NOT GIVEN	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Total	190	..	65	34.2	96	50.5	19	10.0	4	2.1	6	3.2
Hebrew	40	21.0	13	20.0	20	20.8	3	15.8	1	25.0	3	50.0
Afro-American	4	2.1	1	1.5	2	2.1	..	..	1	25.0	..	..
American	31	16.3	11	16.9	18	18.8	2	10.1	..	..	..	..
Italian	62	32.6	22	33.9	32	33.3	6	31.5	..	..	2	33.7
German	4	2.1	3	4.6	..	..	..	..	1	25.0	..	..
Irish	1	0.5	..	..	1	1.0	..	..	..	..	..	..
Miscellaneous	45	23.6	14	21.6	23	23.9	6	31.5	1	25.0	1	16.3
Not given	3	1.6	1	1.5	..	..	2	10.1	..	..	..	..

EXHIBIT 41.—WORKERS ACCORDING TO GENERAL SCORE

PUSH-CARTS AND STANDS

SCORE	GRAND TOTAL		MEN								WOMEN					
			Total		1		2		3		Total		1		2	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Total	195	..	179	91.8	178	99.5	..	..	1	0.5	16	8.2	15	93.3	1	6.7
1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
2	2*	1.0	1*	0.5	..	..	..	..	1	100.0	1*	6.3	..	..	1	100.0
3	6	3.1	6	3.3	6	3.4	..	..	..	..	..	..	..	..	..	..
4	19	9.7	16	8.9	16	9.0	..	..	..	..	3	18.8	3	20.0	..	..
5	36	18.5	32	17.8	32	18.0	..	..	..	..	4	25.0	4	26.8	..	..
6	44	22.6	42	23.4	42	23.5	..	..	..	..	2	12.5	2	13.3	..	..
7	40	20.5	37	20.6	37	20.8	..	..	..	..	3	18.8	3	20.0	..	..
8	27	13.8	27	15.1	27	15.2	..	..	..	..	..	..	..	..	..	..
9	19	9.7	17	9.5	17	9.6	..	..	..	..	2	12.5	2	13.3	..	..
10	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Not given	2	1.0	1	0.5	1	0.5	..	..	..	..	1	6.3	1	6.7	..	..

* Both male and female workers.

EXHIBIT 42.—FOODS ACCORDING TO HEALTH AND GENERAL APPEARANCE OF WORKERS

PUSH-CARTS AND STANDS

SCORE	TOTAL		MILK		POULTRY		MEAT		FISH		VEGETABLES		BUTTER AND CHEESE		CONFECTIONERY		BREAD		PASTRY		DRIED FRUIT		FRUIT		ICE CREAM		EGGS	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Total	289	..	2	0.7	4	1.4	8	2.8	18	6.2	105	36.4	3	1.1	6	2.1	16	5.5	3	1.1	5	1.8	117	40.2	1	0.3	1	0.3
Good	41	14.2	1	50.0	2	50.0	2	25.0	5	27.8	8	7.6	2	66.7	2	33.3	1	6.2	..	..	1	20.0	17	14.5	..	..	..	..
Fair	133	46.0	..	..	..	..	3	37.5	5	27.8	50	47.6	1	33.3	3	50.0	9	56.2	2	66.7	1	20.0	57	48.7	1	100.0	1	100.0
Bad	58	20.0	1	50.0	1	25.0	2	25.0	2	11.1	24	22.8	..	..	1	16.7	2	12.5	1	33.3	..	..	24	20.5	..	..	..	..
Very bad	47	16.3	..	..	1	25.0	..	..	6	33.3	19	18.1	..	..	..	..	2	12.5	..	..	2	40.0	17	14.5	..	..	..	..
Not given	10	3.5	..	..	..	..	1	12.5	..	..	4	3.8	...	..	..	..	2	12.5	..	..	1	20.0	2	1.7	..	..	..	..

NOTE: 2 push-cart stables.

EXHIBIT 43.—SANITATION SCORE ACCORDING TO HEALTH AND GENERAL APPEARANCE OF WORKERS

Push-Carts and Stands

Score	Total		1		2		3		4		5		6		7		8		9		10		Not Given	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Total	194	..	..	..	..	..	..	..	2	1.0	27	13.9	68	35.0	39	20.1	43	22.1	9	4.6	4	2.1	2	1.0
Good	34	17.5	..	..	..	..	..	..	..	..	1	3.7	3	4.4	6	15.4	14	32.6	5	55.6	3	75.0	2	100.0
Fair	87	44.8	..	..	..	..	..	..	1	50.0	8	29.6	30	44.2	27	69.2	18	41.8	2	22.2	1	25.0	..	..
Bad	36	18.5	..	..	..	..	..	..	..	..	7	25.9	21	30.9	3	7.7	3	7.0	2	22.2	..	..	..	..
Very bad	29	14.9	..	..	..	..	..	..	1	50.0	10	37.0	8	11.7	2	5.1	8	18.6	..	..	..	..	..	..
Not given	8	4.1	..	..	..	..	..	..	..	..	1	3.7	6	8.8	1	2.6	..	..	..	..	..	..	..	..

EXHIBIT 44.—FOODS ACCORDING TO SANITARY SCORE

Push-Carts and Stands

Score	Total		Milk		Poultry		Meat		Fish		Vegetables		Butter and Cheese		Confectionery		Bread		Pastry		Dried Fruit		Fruit		Ice Cream		Eggs	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Total	289	..	2	0.7	4	1.4	8	2.8	18	6.2	105	36.3	3	1.0	6	2.1	16	5.5	3	1.0	5	1.7	117	40.5	1	0.4	1	0.4
1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
2	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
3	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
4	3	1.0	..	..	..	..	..	..	1	5.6	1	1.0	..	..	..	..	..	..	..	..	..	..	1	0.9	..	..	..	..
5	45	15.5	1	50.0	2	50.0	..	..	4	22.2	17	16.2	..	..	2	33.3	3	18.8	2	66.7	2	40.0	12	10.2	..	..	..	..
6	111	38.4	..	..	..	..	3	37.5	4	22.2	49	46.6	..	..	..	..	6	37.5	1	33.3	3	60.0	44	37.5	..	..	1	100.0
7	58	20.1	..	..	1	25.0	..	..	3	16.7	22	20.9	1	33.3	1	16.7	3	18.8	..	..	..	..	27	23.1	..	..	..	..
8	54	18.6	1	50.0	1	25.0	5	62.5	2	11.1	14	13.3	2	66.7	2	33.3	3	18.8	..	..	..	..	23	19.6	1	100.0	..	..
9	10	3.5	..	..	..	..	..	..	2	11.1	1	1.0	..	..	..	..	..	..	..	..	..	..	7	6.0	..	..	..	..
10	5	1.7	..	..	..	..	..	..	1	5.6	..	..	..	..	1	16.7	1	6.3	..	..	..	..	2	1.7	..	..	..	..
Not given	3	1.0	..	..	..	..	..	..	1	5.6	1	1.0	..	..	..	..	..	..	..	..	..	..	1	0.9	..	..	..	..

NOTE: 2 push-cart stable—scores 5 and 6.

EXHIBIT 45.—FOODS ACCORDING TO CONDITION OF PUSH-CART

Push-Carts and Stands

Score	Total		Milk		Poultry		Meat		Fish		Vegetables		Butter and Cheese		Confectionery		Bread		Pastry		Dried Fruit		Fruit		Ice Cream		Eggs	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Cleanliness																												
Total	289	..	2	0.7	4	1.4	8	2.8	18	6.2	105	36.3	3	1.0	6	2.1	16	5.5	3	1.0	5	1.7	117	40.5	1	0.4	1	0.4
Good	51	17.6	..	..	..	..	2	25.0	4	22.2	10	9.5	..	..	4	66.7	2	12.5	..	..	..	..	29	24.8	..	..	..	..
Fair	151	52.3	1	50.0	2	50.0	3	37.5	5	27.8	65	61.8	3	100.0	..	..	7	43.7	..	..	1	20.0	62	53.0	1	100.0	1	100.0
Bad	65	22.5	..	..	2	50.0	3	37.5	5	27.8	24	22.8	..	..	1	16.7	4	25.0	2	66.7	3	60.0	21	17.9	..	..	..	..
Very bad	15	5.2	1	50.0	..	..	..	..	2	11.1	5	4.8	..	..	1	16.7	1	6.3	1	33.3	1	20.0	3	2.6	..	..	..	..
Not given	7	2.5	..	..	..	..	..	..	2	11.1	1	1.0	..	..	..	..	2	12.5	..	..	..	..	2	1.7	..	..	..	..
Repair																												
Total	289	..	2	0.7	4	1.4	8	2.8	18	6.2	105	36.3	3	1.0	6	2.1	16	5.5	3	1.0	5	1.7	117	40.5	1	0.4	1	0.4
Good	78	26.9	1	50.0	1	25.0	3	37.5	5	27.8	22	20.8	1	33.3	3	50.0	4	25.0	..	..	..	..	38	32.5	..	..	..	..
Fair	181	62.7	..	..	3	75.0	3	37.5	8	44.5	75	71.3	2	66.7	2	33.3	8	50.0	2	66.7	5	100.0	72	61.5	1	100.0	..	..
Bad	17	5.9	1	50.0	..	..	2	25.0	2	11.1	5	4.8	..	..	1	16.7	..	..	1	33.3	..	..	4	3.4	..	..	1	100.0
Very bad	3	1.0	..	..	..	..	..	..	..	..	3	3.0	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Not given	10	3.5	..	..	..	..	..	..	3	16.7	..	..	..	..	..	..	4	25.0	..	..	..	..	3	3.6	..	..	..	..

Note: 2 push-cart stables, scores bad.

EXHIBIT 46.—FOODS ACCORDING TO SURROUNDINGS
PUSH-CARTS AND STANDS

SCORE	TOTAL		MILK		POULTRY		MEAT		FISH		VEGETABLES		BUTTER AND CHEESE		CONFECTIONERY		BREAD		PASTRY		DRIED FRUIT		FRUIT		ICE CREAM		EGGS	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
CONDITION OF STREET																												
Total	289	..	2	0.7	4	1.4	8	2.8	18	6.2	105	36.3	3	1.0	6	2.1	16	5.5	3	1.0	5	1.7	117	40.5	1	0.4	1	0.4
Good	14	4.8	..	..	..	..	..	..	3	16.7	2	2.0	..	..	1	16.7	2	12.5	..	..	..	..	6	5.1	..	..	..	..
Fair	173	59.8	1	50.0	1	25.0	4	50.0	8	44.5	64	60.8	2	66.7	4	66.7	6	37.4	2	66.7	4	80.0	75	65.1	1	100.0	1	100.0
Bad	78	26.9	..	..	2	50.0	1	12.5	4	22.2	33	31.3	1	33.3	1	16.7	5	31.3	1	33.3	1	20.0	29	24.8	..	..	..	..
Very bad	14	4.8	..	..	1	25.0	..	..	3	16.7	4	4.0	..	..	..	..	1	6.3	..	..	..	..	5	4.3	..	..	..	..
Not given	10	3.5	1	50.0	..	..	3	37.5	..	..	2	2.0	..	..	..	..	2	12.5	..	..	..	..	2	1.7	..	..	..	..
CONDITION OF GUTTER																												
Total	289	..	2	0.7	4	1.4	8	2.8	18	6.2	105	36.3	3	1.0	6	2.1	16	5.5	3	1.0	5	1.7	117	40.5	1	0.4	1	0.4
Good	7	2.4	..	..	..	..	..	..	2	11.1	..	..	..	..	1	16.7	2	12.5	..	..	..	..	2	1.7	..	..	..	..
Fair	82	28.3	..	..	1	25.0	3	37.5	4	22.2	30	28.6	2	66.7	2	33.3	2	12.5	..	..	..	..	37	31.6	1	100.0	..	..
Bad	104	36.0	..	..	..	..	2	25.0	5	27.8	39	37.1	1	33.3	1	16.7	5	31.3	1	33.3	1	20.0	49	41.8	..	..	..	..
Very bad	86	29.7	1	50.0	3	75.0	..	..	7	38.9	34	32.2	..	..	2	33.3	5	31.3	2	66.7	4	80.0	27	23.1	..	..	1	100.0
Not given	10	3.5	1	50.0	..	..	3	37.5	..	..	2	1.9	..	..	..	..	2	12.5	..	..	..	..	2	1.7	..	..	..	..

NOTE: 2 push-cart stables, 1 fair, 1 bad.

EXHIBIT 47.—FOODS ACCORDING TO DRAINAGE
PUSH-CARTS AND STANDS

SURFACE DRAINAGE	TOTAL		MILK		POULTRY		MEAT		FISH		VEGETABLES		BUTTER AND CHEESE		CONFECTIONERY		BREAD		PASTRY		DRIED FRUIT		FRUIT		ICE CREAM		EGGS	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Total	289	..	2	0.7	4	1.4	8	2.8	18	6.2	105	36.4	3	1.1	6	2.1	16	5.5	3	1.1	5	1.8	117	40.2	1	0.3	1	0.3
Yes	207	71.7	2	100.0	3	75.0	5	62.5	9	50.0	81	77.2	2	66.7	5	83.3	9	56.2	3	100.0	5	100.0	82	70.0	..	..	1	100.0
No	65	22.5	..	..	..	..	..	..	9	50.0	18	17.1	1	33.3	1	16.7	6	37.5	..	..	..	..	29	24.8	1	100.0	..	..
Not given	17	5.9	..	..	1	25.0	3	37.5	..	..	6	5.7	..	..	..	..	1	6.2	..	..	..	..	6	5.1	..	..	..	..

NOTE: 2 push-cart stables.

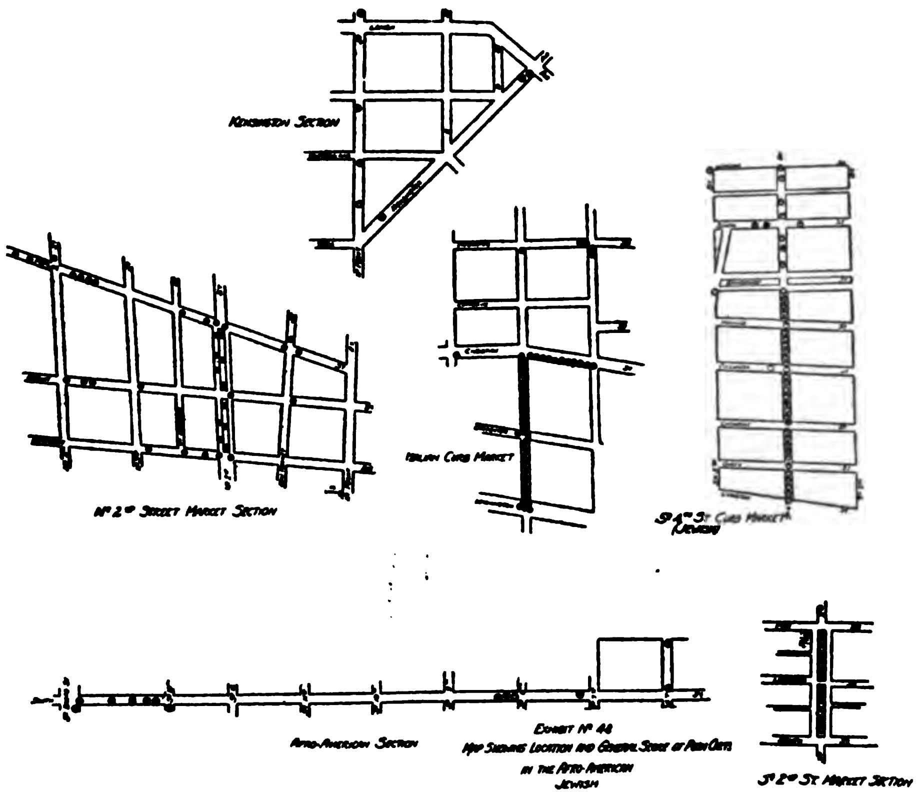
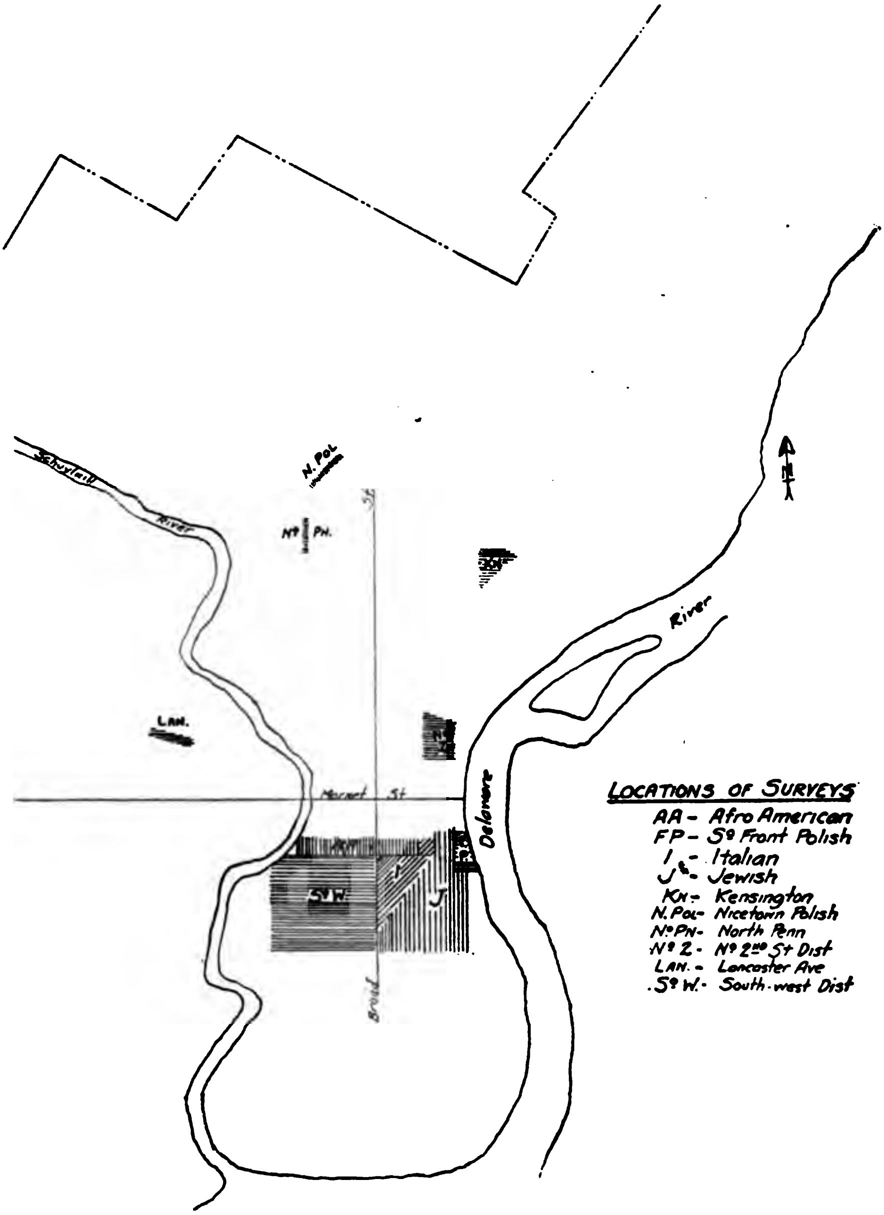


Exhibit No 44
Map Showing Location and General Scope of Push Carts
in the Afro-American
Jewish
Italian
Kensington
No 2nd St
and So 2nd St Surveys
For Scale take ⅛ of Width in Circle Thus ○ ●


Schuylkill
River
N. POL
N° PH.
St
Broad
LAN.
N° 2
Market St
Delaware
FP
I
J
S° W.
River
N
LOCATIONS OF SURVEYS
AA - Afro American
FP - S° Front Polish
I - Italian
J - Jewish
KN - Kensington
N. POL - Nicetown Polish
N°PN - North Penn
N° 2 - N° 2ND St Dist
LAN. - Lancaster Ave
S° W. - South-west Dist

FOOD INSPECTION SERVICE IN PHILADELPHIA

BUREAU OF MUNICIPAL RESEARCH OF PHILADELPHIA

[*Letter of Transmittal*]

BUREAU OF MUNICIPAL RESEARCH

RALPH BOWMAN, *Director*
FREDERICK P. GRUENBERG, *Assistant Director*
ROBERT E. TRACY, *Secretary*

FREDERICK A. CLEVELAND, *Advisory Director*

PHILADELPHIA, April 14, 1915.

DR. S. LEWIS ZIEGLER, *Director*,
Department of Public Health and Charities,
Philadelphia.

Dear Sir: In the fall of 1914 the Phipps Institute, engaged in a study of food conditions in the city of Philadelphia, invited the University of Pennsylvania and the Bureau of Municipal Research to join with it. It was the understanding that Phipps Institute would study conditions of places where food was on sale, the University of Pennsylvania codify the laws and ordinances of the state and city relating to the sale of foodstuffs, and the Bureau of Municipal Research survey the inspection service of the federal, state and city governments.

In joining the other agencies in this study the Bureau of Municipal Research stipulated that (*a*) any report of conditions it found should be submitted first to the Bureau of Health for agreement as to facts and, (*b*) that any criticisms or constructive suggestions the Bureau made should be submitted first to the Director of the Department of Health and Charities, the Chief of the Bureau of Health and to the Health Committee of Councils before any publicity was given to the report.

Preliminary to entering upon the study, Mr. Gruenberg and I called upon Dr. Harte, your predecessor, and Chief Vogleson, outlined the proposed survey and requested entrée to the Bureau and its records. Dr. Harte and Chief Vogleson cordially granted our request and assured us of their hearty co-operation.

The Bureau's survey is completed. Its report of conditions has been submitted to the Bureau of Health and returned with their corrections. I now have the honor of presenting to you for your consideration the report (in duplicate) of the Bureau's findings, criticisms, and constructive suggestions. I am sending a copy of the report also to Dr. Trinkle, chairman of the Committee of Health of Councils.

May I at this time in behalf of the Bureau of Municipal Research express our hearty appreciation of the assistance and co-operation of Chief Vogleson, Chief Milk Inspector Hankele, Chief Meat Inspector McKibben, and the other members of the Bureau of Health with whom we came in contact in making this survey.

Respectfully submitted,
RALPH BOWMAN, *Director*.

SUMMARY

The survey has disclosed a number of limitations and some objectionable features about the Food Inspection Service:

1. The city has control only over milk and its fluid derivatives and meat, cattle, fish, and meat food products.
2. The inspection force is too small—four (4) veterinarians obviously cannot inspect all animals slaughtered at sixty-eight (68) different slaughter houses the way they are distributed over Philadelphia.
3. Responsibility in the office is divided between the Chief Meat and Cattle Inspector and the Chief Milk Inspector; neither, therefore, can be held strictly accountable.
4. The office arrangement—one room incompletely divided into three—is very unsatisfactory.
5. There is no standardization of salaries.
6. No provision has been made for increase in salaries as a reward of merit or as an appreciation of length of service.
7. Veterinarians as compared with other cities are underpaid.
8. No allowance for clerical service is made in the appropriation to the service.
9. A milk inspector is retained in the office for clerical work practically all the time.
10. No allowance for traveling expenses and postage is made in the appropriation to the Service.
11. Inspectors have no daily outline of work—simply follow their own inclinations.
12. Veterinarians keep no time sheets and apparently have very indefinite working hours.
13. Stores are not scored on every inspection visit because of an insufficient supply of score cards.
14. Milk licenses once issued are good for a lifetime.
15. The same printed form is used for various kinds of licenses.
16. Milk Inspection Service issues "Five-day notices," and then gives three weeks or two months, as the case may be, for compliance with requirements.
17. Neglect to publish results of bacteriological examinations is a direct violation of Paragraph 9, Ordinance 300.

These limitations and objectionable features may be overcome by the following means:

1. Extension of control over all things to be eaten or drunk.

2. Increase in the number of veterinary inspectors or reduction in the number of slaughter houses.
3. Formation of a Division of Food Inspection and appointment of a Chief of the Division.
4. Assignment of different office rooms to the Service, or a complete subdivision of the ones now occupied.
5. Salary standardization.
6. Provision of increase for merit and continued service.
7. Higher salaries for veterinarians.

8 and 9. Provision for clerical force.

10. Appropriation for traveling expenses and postage.
11. Provision of daily outline of work for inspectors.
12. Definite working hours and time sheets for veterinarians.
13. Sufficient supply of score cards.
14. Annual issuance of milk licenses.
15. Different license forms for different kinds of licenses.
16. Issuance of notices for various periods of time.
17. Publication of results of bacteriological examinations.

A. GENERAL DESCRIPTION OF INSPECTION SERVICE:
   1. Municipal inspection service.
   2. State inspection service.
   3. Federal inspection service.

B. CRITICISM:
   1. Municipal inspection service.

C. CONSTRUCTIVE SUGGESTIONS:
   1. Municipal inspection service.

D. EXHIBITS.

GENERAL DESCRIPTION OF INSPECTION SERVICE

1. *Municipal Inspection Service:*
   - *a.* Origin and growth.
   - *b.* Extent of control.
   - *c.* Organization and expenditures.
   - *d.* Office.
   - *e.* Duties:
     - Milk inspectors.
     - Meat inspectors.
   - *f.* Equipment:
     - Milk inspectors.
     - Meat inspectors.

    g. Hours of work.
    h. Work records.
    i. Inspection districts.
    j. Inspection.
    k. Complaints.
    l. Instruction of new inspectors.
    m. Supervision.
    n. Bacteriological and chemical examinations of milk.
    o. Punitive measures taken.
    p. Working relations with other divisions.
    q. Education of dealers and general public.

2. *State Inspection Service.*
3. *Federal Inspection Service.*

A. GENERAL DESCRIPTION OF INSPECTION SERVICE

1. MUNICIPAL INSPECTION SERVICE

a. Origin and Growth.—Food inspection service in Philadelphia is comprised of what were originally known as the Division of Milk Inspection and the Division of Meat and Cattle Inspection. These divisions were established in accordance with acts of legislature to provide for the protection of the public from adulteration and dilution of milk and from the sale of meat and meat-food products unfit for food.

The Division of Milk Inspection was first established in 1889 by the appointment of a chief milk inspector. In 1890, the chief was given five assistants, two bearing the title of assistant inspector, and three that of collector. In 1893, the force was increased to four assistant inspectors and five collectors. In 1904, four additional assistant inspectors and three additional collectors were appointed, making eight of each. In 1907, the collectors were made regular assistant inspectors and the title of collector was dropped. Since 1904, there has been no addition to the force, which now as then consists of a chief milk inspector and sixteen (16) assistant inspectors. During this time, however, the work has increased greatly. In 1904, the daily milk supply of the city was 305,700 quarts, while in 1914 it was 480,000 quarts, an increase of 174,300 quarts, or 57 per cent. To this increase in quantity to be inspected must be added also the increase in work due to pasteurization and bottling of milk (Exhibit C).

Meat Inspection service developed from the assignment in 1891 of a detective in the Bureau of Police to the detection of dealers handling unwholesome meats. This special officer was given temporary assistants from time to time as needed. In 1904, the Bureau of Health took over this work and a chief meat inspector and six (6) assistants were appointed. In 1910 one additional inspector was appointed. Since then the force has not been increased. The work, however, has increased to such an extent that this year it was more than the veterinarians could do to inspect the cattle for slaughter; almost all the hogs, sheep, and goats were killed without inspection (Exhibit D).

b. Extent of Control.—The city has control only of milk and its fluid derivatives and fish, poultry, meat, and meat-food products. Acting as Special Agents of the Dairy and Food Commissioner, the milk inspectors at times extend the scope of their work, but for the most part they are kept busy attending to their specific duties, and complaints about other foodstuffs are, as a rule, turned over to the state agents.

c. Organization and Expenditures.—The work of Food Inspection Service may be considered under three heads: milk inspection, meat and cattle inspection, and general office work. In 1914 the total expenditure for this service was $27,352, which amounted to $0.0166 per person in Philadelphia (Exhibits A, E, and F).

The revenue from licenses in 1914 was $13,996. This, therefore, reduces the city's actual outlay for food inspection from $27,352 to $13,356 or $0.0081 per capita.

The milk inspection work is conducted by a chief inspector of milk—salary $1900—and sixteen (16) assistants—salary $1020 each (Exhibit A).

The inspection of cattle, fish, meat, and meat-food products is carried on by the chief inspector of meat and cattle—salary $1350—and seven (7) assistants—salary $1000 each (Exhibit A).

No allowance is made for expenses.

No clerk or stenographer is provided for by Councils for the Food Inspection Service, but a clerk in the Bureau of Health is detailed there. The clerical work of the service, however, cannot be handled by one person, so it is necessary to have an inspector spend most of his time in the office issuing licenses, filling out cards, filing, etc. During rush periods, two inspectors may be needed in the office.

d. Office.—The work of food inspection, both milk and meat, is conducted from one room. Here the records are kept, cards filed, notices and licenses issued, complaints received, reports written, etc. This room is quite large and has been partially subdivided into a reception room, an outer and an inner office, but whatever is said in any part of the room can be heard quite distinctly all over it. Foreign-born dealers who scarcely understand or speak English often come in for instructions, for a license, or to complain about the revocation of a license, and their failure to comprehend what is said to them usually results in very loud talking. During such periods, and they are frequent, it is practically impossible to do work which requires care and thought.

e. Duties—(1) *Milk Inspectors.*—The duties of the chief milk inspector are to plan the work of the service, superintend the office work, and supervise the work of the assistant inspectors.

One assistant inspector is assigned to the collection of samples for bacteriological analysis. These samples are taken in every part of the city from each kind of milk-handling establishment,—railroad and trolley platforms, wagons, bottling plants, stores, and restaurants.

Two assistant inspectors devote their whole time to the inspection of pasteurizing plants. They visit all plants in the city, inspect the pasteurizing apparatus, note the sanitary conditions and suggest improvements.

Another assistant inspector is assigned to the office for clerical work.

The remaining twelve (12) inspect the milk and the sanitary conditions in all milk-handling establishments in the city with the exception of pasteurizing plants. These men make physical tests for temperature and gravity and fill out official score cards when inspecting restaurants and stores.

In taking the lactometer and temperature test for milk, one or more bottles may be tested at the same store. After the reading has been taken, the milk is poured back into the bottles, the caps replaced, and the bottles returned to the ice-box.

Owing to the small number of regular meat inspectors, these twelve milk inspectors are assigned also to the inspection of retail meat and fish markets and stores. They see that these are licensed, note the sanitary condition of the places, and the quality of food sold. The markets are inspected in the same manner as stores. For the last three years, however, no licenses have been granted to dealers selling meat in the municipal markets because of the unsanitary condition of these places. They are open to all the dirt and dust of the streets and in the summer are entirely unscreened.

Two of these milk inspectors also devote a part of their time to the inspection of dairies within the city limits. These are scored for equipment and sanitation.

The inspectors have no daily outline of work prepared for them. Each one follows a system of his own or works without system. If the office wishes to reach him, therefore, a message is telephoned to his home; but the inspector himself cannot be reached until he has returned from his day's work.

The city milk and meat inspectors have been appointed Special Agents of the Dairy and Food Commissioner, and the meat inspectors of the State

Livestock Sanitary Board. The meat inspectors also have been sworn in as Special Officers of the Bureau of Police in such cases as police powers could in whole or in part be conferred upon an inspector.

(2) *Meat and Cattle Inspectors.*—The chief meat and cattle inspector plans and supervises the work of his assistants.

Four of the assistant inspectors are veterinarians who work entirely on the ante- and post-mortem inspection of animals; they oversee the sixty-eight (68) slaughter houses in the city, which do not have federal inspection. They also engage in private practice.

The other three (3) inspectors are laymen and are assigned one to the wholesale meat house, a second to the wholesale fish market, and a third to preparing plants and chicken slaughter houses.

f. Equipment—(1) *Milk Inspectors.*—Inspectors of stores are equipped with a small black grip, containing a street book giving the stores in their districts, a Board of Health seal and sealing wax, meat and milk score cards, notices, a bottle cap remover, a milk cylinder, two lactometers and thermometers for testing milk, one or two towels, an electric pocket lamp for flashing in dark corners of ice-boxes, condemnation tags to paste on rusted cans, and in the summer, a leaden case containing sulphuric acid, and one or two test tubes for formaldehyde testing.

(2) *Meat Inspectors.*—Meat inspectors are equipped with a black grip containing report blanks, quarantine blanks, notices, retaining tags, ear punch and tags, a trier, plier, three official stamps—passed, retained, condemned—and a pad. They furnish their own knives.

g. Hours of Work.—Milk inspectors have a forty-hour working week. This time is not distributed regularly throughout the week, but depends upon the requirements of the work. At times an inspector's duty may call him out, to a farm or milk platform, at four or five o'clock in the morning or on Sunday, and this, of course, shortens his hours of work on other days. As a matter of fact, a study of the inspector's time reports shows that in July, 1914, only half of the inspectors whose reports were filled out put in the full 40 hours a week. The average working week for all the inspectors whose reports were filled out was 41 hours, 36 minutes. The lowest figures for the week were 35 hours, 3 minutes, and the highest, 48 hours, 16 minutes. In November the average was 45 hours for each man, the lowest figures being 37 hours, 51 minutes, and the highest, 56 hours, 55 minutes. In July, six men averaged the full 40-hour week, while six did not, and in November, eleven worked the required time, while two did not. Four men made out no time reports for July, and three of the same four made none for November. These figures are for full working weeks, vacations and holidays having been counted out (Exhibit B). Eight men did not put in their weekly or monthly totals, and one man wrote in his total column 8 hours each day and 5 on Saturday, when in almost every case this was not the actual number of hours between the time he began and finished working.

Meat inspectors do not have any specified hours of work and so do not keep time records. The amount of work, however, which they have to do, and which their work reports show that they do, is such that they must of necessity put in far more time than was originally expected of them. They are subject to call at any time.

h. Work Records.—In 1913 the inspectors recorded their work in large, cumbersome books, each man having his own book. They came to the office once each day, wrote up their daily inspections, and at the end of each month, a general summary. To collect statistics from such records requires an excessive expenditure of time and labor.

In March, 1914, a new system was adopted. Each inspector has monthly cards that may be filled in daily and totaled at the end of each week and month. These are then filed in the inspectors' folders. Material kept in this way is easily available for statistical purposes.

Meat inspectors keep daily records of work performed and also weekly records on long printed forms, 10 by 14 inches, which are then folded up and filed in each inspector's file.

Score cards of dairy inspections are made out on every visit and an attempt made to raise the grading by careful supervision: 80 is the score to sell raw milk, and 50 to sell milk for pasteurization. For the period between 1907 and 1912 there are about 100 score cards on file. Since 1913, however, dairies have been scored regularly.

A card catalogue of the dealers and the farmers from whom they received their milk has been started, but has not been kept up to date, as this would necessitate checking up the data every few months and then having the cards corrected. This would require a good bit of clerical assistance.

Stores are scored three or four times a year and these cards filed under the storekeeper's name. The inspectors were formerly instructed to fill out a score card on every visit to a store, and to send these cards in to the office daily as a record of work accomplished. To do this about 100,000 cards per year would be needed, and as the supply in 1914 was only 40,000, other arrangements had to be made. Sending the cards daily raised the question of postage, also. The appropriation to the department is not large enough to cover this expense, and the inspectors' salaries are too small for them to be required to meet it.

Slaughter houses and preparing plants are scored numerically once each year.

Records of inspections of milk stations are filed under the name of the dealer, since a milk license is issued to the man and is still good even though he move from place to place within the city.

Records of inspections of slaughter houses and all meat handling places are filed according to location, because in this case licenses are issued for the place as well as to the person.

Milk licenses are issued for an indefinite length of time, until revoked because of violation of rules and regulations. Meat, cattle, and poultry licenses are good for one year only.

The same printed form is used for a license to sell meat, poultry, and fish, and to conduct a slaughter house or preparing plant. The business to be conducted by the dealer applying for a license is stamped somewhere on the sheet by means of a rubber stamp; as—"meat," "poultry," "fish," "slaughter," or "preparing plant." A separate license must be obtained, however, for selling each of these products and for slaughter houses or preparing plants.

All correspondence pertaining to a given dealer is filed in a large envelope bearing his name. Letters concerning abattoirs are kept in the same manner.

i. Inspection Districts.—Inspection districts are specifically defined and mapped out according to conditions; districts in congested sections of the city are much smaller than those in suburban sections. There are thirteen inspection districts for milk and meat stores, and four for slaughter houses. One of the store districts, however, is vacant, since the inspector supposed to have this district has been assigned to clerical work in the office (Exhibits K and L).

During the past year milk inspectors have inspected both milk and meat stores in their districts. This has practically doubled the number of stores on each inspector's route, thereby reducing frequency of inspection, although the number of inspections has increased.

j. Inspection.—The total number of milk inspections in 1914 was 130,118 as compared with 90,751 in 1913, an increase of 39,367 or 40 per cent. (Exhibit C). The number of meat inspections for these years was 129,943 and 99,395 respectively, an increase of 30,548 or 31 per cent. (Exhibit D).

Frequency of inspection varies. In congested sections the inspectors cover their districts in about six weeks or two months, thus visiting the stores six or eight times a year. In the larger districts, where there is more ground to cover, reinspections occur only five or six times a year. These districts, however, usually do not require so much attention as in the more densely populated sections.

Milk inspectors inspect meat and milk stores, railroad and trolley platforms, pasteurizing and bottling plants, restaurants, hotels, wagons, and dairy farms within the city.

Meat inspectors inspect stores, abattoirs, stock-yards, storage houses, wholesale houses, markets, market trains, and preparation plants.

The inspection of market trains does not amount to very much, as even for the skilled inspector it is almost impossible to detect diseased conditions, unless in advanced stages, after the meat has been dressed. Besides meat coming in on trains, considerable is brought in by farmers and this entirely escapes inspection.

There are in the city, approximately, 160 dairy farms, 4 ferries, 129 pasteurizing and bottling plants, 11 railroad platforms, 7 trolley platforms, 10,000 stores, 69 abattoirs (city inspected), 12 abattoirs (federal inspected), 23 market houses, 88 preparing plants (city inspected), 47 preparing plants (federal inspected), 2 stock-yards, 42 wholesale meat houses.

k. Complaints.—In 1913, there were two hundred ninety-two (292) complaints against dealers and two hundred forty-eight (248) in 1914. These are very often the complaints of competing dealers and in the past year have been mostly about keeping chickens. An inspector is detailed immediately to investigate a signed complaint and the result of his investigation is reported to the division. Further instructions are then given to him, or if of sufficient importance the case is taken up by the chief milk or meat inspector. About 80 per cent. of the complaints, however, are not signed; these are referred to the inspectors to be investigated in the regular course of their work.

Although there is a good deal of grumbling, but few actual complaints about inspectors are received from dealers—about six (6) per year. Such complaints the chief inspectors investigate personally and usually find unfounded.

Eight inspectors were accompanied on their day's work by the investigators, and in every case they were very courteous and obliging. In their treatment of dealers they were, without exception, pleasant and agreeable although insistent and firm in their commands "to clean up." In some districts the mere suggestions of cobwebs or dirt sent the storekeeper hurrying for a broom, but with Russian, Jewish, Italian, and Polish dealers, this problem was more difficult to handle. The people here seem entirely to lack standards of cleanliness, and while an inspector was persuading a dealer to "clean up," eight or ten of his customers joined in the argument, taking sides with the dealer, and insisting that the place was clean enough and everything was just as they desired it. This, of course, made it very hard for the inspector to do his work. In such districts it is necessary to be very emphatic and to exercise all due authority in order to accomplish anything; and even then, without constant supervision, results are not lasting.

Only one of the inspectors accompanied gave the impression of carelessness and lack of method in his work.

l. Instruction of New Inspectors.—Milk and meat inspectors come under the Civil Service Law. After receiving an appointment, the inspector spends a day in the office and there is instructed as to the methods and procedure of the service. The chief inspector then takes him out on the street for a day and after that an assistant inspector accompanies him several days or two weeks if necessary. The time which a new inspector spends with an experienced one depends entirely upon the facility with which he grasps the work.

m. Supervision.—The chiefs supervise the work of their assistants. They go out with the men occasionally, or check up their score cards. They soon learn which men are reliable and then keep the doubtful ones up to the standard by close supervision.

n. Bacteriological and Chemical Examinations of Milk.—The inspector who collects bacteriological samples of milk takes them to City Hall before one o'clock each day and they are then sent by wagon to the Bacteriological Laboratory (under the Division of Laboratories), at Second and Luzerne Streets. Tests are made here and the results reported to the Food Inspection Office. In cases where the bacteriological count runs above the limit of 50,000 per c.c., notices are sent to the dealers. More samples are taken, and constant watch kept until the milk again reaches the standard.

Of the samples taken in 1914 for bacteriological analysis, 49 per cent. were below the count allowed (50,000 per c.c. according to rule in effect July 1, 1915), 36 per cent. had between 50,000 and 500,000 bacteria per c.c., 14 per cent. between 500,000 and 10,000,000, and 1 per cent. over 10,000,000. The results of milk examinations are not published.

Chemical examinations of milk are made when the lactometer test shows evidence of adulteration. A sample of such milk is taken to the office and a portion of it is tested by the chief milk inspector. If he finds the milk to be adulterated, he sends the remaining portion of the sample to the city chemist in order that his findings may be confirmed.

o. Punitive Measures Taken.—With the exception of chicken slaughter houses, the chief milk and meat inspectors do not depend a great deal on prosecution to obtain results. They prosecute now and then in flagrant cases, but as a rule, try to improve conditions by persuasion rather than by force. On a first offense, the dealer is warned by the inspector and given instructions as to what measures he should take in order to avoid further trouble. On a second offense, in the case of milk-handling establishments and stores, the inspector may issue a "five-day notice." In the case of slaughter houses and preparing plants, notices are issued for various periods of time. In 1914 two hundred and thirty-one (231) such notices were issued, sixty-three (63) of which were complied with. If no attempt is made to comply with the notices, licenses are revoked or prosecutions instituted. Fourteen (14) licenses were revoked in 1914, and fifty-eight (58) prosecutions instituted. In the other ninety-six (96) cases, extensions of time were granted. If watered milk is found in the hands of a producer, he is prosecuted on the first offense. In 1914 very little milk was found to be watered: only about .0009 per cent., and 80 per cent. of that was watered during transportation. The money from the milk adulteration fines goes into the state treasury, since the fines are imposed under a state law. The city treasury receives the money from violations of the license acts. It is very seldom necessary to fine the same person twice; only one second prosecution has been instituted in the last two years.

p. Working Relations with Other Divisions.—Before a new slaughter house is built the location must be approved by the Board of Health. The plan is then submitted to the Chief Meat Inspector, and upon his approval a copy is sent to the Division of Sanitation for approval and a copy filed also with the Division of House Drainage.

q. Education of Dealers and General Public.—Food inspection work is discussed by the Director of the Department of Public Health and Charities in his monthly bulletins at appropriate times.

Articles written by the chief milk or meat inspector or by assistant inspectors have been published from time to time in the national milk magazines.

The chiefs give illustrated lectures in high schools and before women's clubs and business associations, when opportunities permit.

During the summer the "Public Ledger" ran a series of articles written by the Chief Milk Inspector.

Circulars on rat extermination are being given out with 1915 meat licenses and they will be distributed by mail also in 1915, so that all storekeepers will receive them.

Cotton discs showing the sediment tests for milk are sent to the dairymen and have proved to be quite educational in the matter of securing cleaner milk.

2. STATE INSPECTION SERVICE

State food inspection in Philadelphia is carried on by the Dairy and Food Commission. There are nineteen (19) agents in Pennsylvania; one (1) receives a salary of $1800 per year, seventeen (17) receive $1500 each, and one (1), a woman, receives $1080. Of these, one man spends about three days a week in Philadelphia and another is here practically all of the time. Traveling expenses are paid by the state.

These agents inspect eggs, milk and cream, ice cream, cheese, butter, oleomargarine, lard, meat, sausage, fruits, vegetables, spices, non-alcoholic drinks, vinegar, and fruit syrup, and see that certain acts—Pure Food, Cold Storage, etc.—are enforced. They have no authority to confiscate condemned food, they simply stamp it "not to be sold in Pennsylvania."

In 1914, up to December 1, the state agents brought to issue three hundred fifty-eight (358) prosecutions in Philadelphia. Almost without exception, these cases were convictions and caused little trouble with the dealers, as they wished to avoid newspaper publicity.

State inspectors do little work on milk in Philadelphia. Upon request, as a result of watered milk, they inspect outlying farms which send milk into the city.

State inspectors work independently of city inspectors, but co-operate with them by investigating cases referred to them by the city.

The State Livestock Sanitary Board does some food inspection work in cities and towns that do not have municipal inspection, but it does little in Philadelphia except to quarantine contagious diseases among livestock and inspect dairy herds at dairies outside, which send milk into the city. Inspectors are changed from one kind of work to another as occasion requires; at present all are working on foot and mouth disease.

These agents are all veterinarians and receive $1800 to $2000 per year and expenses.

3. FEDERAL INSPECTION SERVICE

Under Article 1, Section 8, the General Welfare clause of the Constitution of the United States, the Bureau of Chemistry holds authority to enforce the Food and Drugs Act, and the Bureau of Animal Industry to inspect meat and meat products handled in interstate commerce.

At present, the Bureau of Chemistry has two inspectors in Philadelphia. They go chiefly to the railroads, wharves, and freight yards, and occasionally visit factories to see conditions under which food products are manufactured, methods used, labels on hand, etc. They cannot interfere, however, until they have had samples of the product taken in an interstate shipment, examined, and found adulterated or misbranded. The inspectors take samples only of products which they think are adulterated or misbranded and consequently will give the government ground for prosecution. These samples are taken to the Food and Drug Inspection Laboratory. If found to be adulterated, the case is reported to Washington. The district attorney is then instructed to institute criminal proceedings or to have the court issue a libel of condemnation by which he is empowered to seize the goods. If in the meantime the goods have disappeared, the inspectors must watch for another shipment.

Besides police work, the federal government also does constructive work in regard to the handling of certain foods. The Bureau of Chemistry maintains a Food Research Laboratory in Philadelphia, which makes a scientific study of eggs, poultry, and fish, publishes facts learned, and tries to educate both the producer and the consumer.

The Bureau of Animal Industry details seventy (70) inspectors to the Philadelphia station, nine (9) of whom are assigned to outlying towns. Twenty-two (22) are veterinarians who begin at a salary of $1400 a year and advance $200 each third year of service until they receive $1800 per year. Expenses are paid by the government. The lay inspectors—salary $840 to $1200 per year—act as assistants to the veterinarians, two or more being assigned to a slaughter house under the direction of one veterinary inspector. After five years of service a lay inspector may be assigned to packing-house duty. Inspectors are on duty in packing houses and during killing in slaughter houses which offer meat for shipment in interstate or foreign commerce, and occasionally they make inspections of butcher shops which sell fat to be made into lard, oleo, etc. They take samples of sausage and other meat products and send them to the chemical laboratory in Washington for examination.

Two or three supervisors go around the city to see that the inspectors are doing their work properly and that killing is not going on at slaughter houses in the absence of an inspector. There are twelve (12) abattoirs and forty-seven (47) preparing plants under federal supervision.

The Bureau also investigates general construction of slaughter houses, kinds of material most suitable for floors, tables, etc., and, upon request, gives information regarding such matters. The regular inspectors make no suggestions to the managers of establishments in regard to general arrangement of the plant but report changes which they think advisable. Those in charge of the station then investigate these cases and decide what shall be required. In this way uniformity of action is attained.

There is no duplication of work by city and state agents and federal inspectors in Philadelphia. The city and state have so few men for the amount of work which they have to do that they seldom visit establishments under federal inspection.

B. CRITICISM

1. MUNICIPAL INSPECTION SERVICE

a. Growth of Food Inspection.—Although the work of milk and meat inspection has increased greatly in the last ten years, there has been no increase in the milk inspection force since 1904, nor in the meat force since 1910. Since 1904 there has been an increase of 57 per cent. in the average daily milk supply of the city, yet the same number of men have to see that it is not adulterated nor diluted, that it is bottled, and also, since July, 1914, that it is pasteurized. The ordinance becoming effective July 1, 1914, requiring pasteurization of all milk sold in the city except that graded "certified," has added greatly to the work of milk inspection, yet no provision has been made for more assistants.

The recent crusades against tuberculosis have greatly increased the demand for better meat. Acting on the principle that tuberculosis is found more frequently in cattle than in other animals used for food, most of the inspectors' time has been devoted to inspecting cattle. But tuberculosis is also very prevalent among hogs. Chief Melvin, U. S. Dept. Agriculture, says: "One per cent. of the cattle and two per cent. of the hogs inspected by the United States Government have tuberculosis,"* furthermore, other diseases such as trichinosis may be directly transmitted to man by meat; and poisonings, septicemia, pyemia, etc., often result from eating meat infected by certain other diseases.

Yet since there are so few inspectors that it takes most of their time to inspect cattle, practically all of the hogs, sheep, and goats slaughtered in Philadelphia last year were killed without either ante- or post-mortem inspection. Ante-mortem inspection is important, as some diseases, tetanus and rabies, cannot be detected after death.

b. Extent of Control.—While it would be desirable to attain one hundred per cent. efficiency in the inspection of foods already under municipal supervision before assuming added responsibilities, still present needs demand extension of control. If two state inspectors, working only part time, can find three hundred fifty-eight (358) violations of state food laws in Philadelphia in less than a year, a special corps of city inspectors would surely have a good field for service.

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* 242 Bureau of Animal Industry, Circular 185.

Fruit, vegetables, candy, cakes, etc., are often exposed for sale on the streets. They are usually unscreened and uncovered, and almost invariably baskets of fruit and vegetables are standing on the sidewalks or, if inside, on the floor. Meat, bread, and pastry are constantly exposed on counters where they are contaminated by flies and incessantly handled by prospective buyers.

There is practically no supervision of hotels, restaurants, and bakeries. The only control which the city now has in these places is over milk.

c. Organization and Expenditures.—Responsiblity in Food Inspection Service is divided between the Chief Milk Inspector and the Chief Meat and Cattle Inspector, both occupying the same office. This results in division of authority and lack of responsibility in the office, since neither chief feels that he is in full charge.

Notwithstanding the fact that the clerical work of the Service is very heavy, no allowance is made in the appropriation for a clerical force. The practice of keeping inspectors in the office to issue licenses, file cards, etc., is objectionable. While this may not be a violation of the letter of the law, it surely is of the spirit. It also decreases the number and efficiency of the inspection force. Moreover, $1,020 is too much to pay for such services. Furthermore, an inspector may not be a good clerk and ought not to be expected to do the work as well as a person trained for the position.

In 1914 Philadelphia, the third largest city in the United States, spent $27,352, or a little over a cent and a half ($0.0166) per person, for food inspection. This is less than that spent by New York, Chicago, Boston, Pittsburgh, or Baltimore, either in total or per capita. Baltimore, with a population of only 578,000 as compared with Philadelphia's 1,650,000 persons, spent $28,980, or five cents ($0.0501) per person. New York spent $173,730, or three cents ($0.0316) per person; Chicago, the second largest city in the United States, spent $134,460, or over five and a half cents, ($0.0562) per person; Boston, with a population of 733,562, spent $53,234, over seven cents ($0.0726) per person; and Pittsburgh, population 600,000, spent $59,973, or almost ten cents ($0.0999) per person. Thus, although Philadelphia stands third according to population, it stands at the bottom of this list in expenditures for the protection of its food supply (Exhibits C and D). It is hardly to be supposed that food in Philadelphia is so much better than in other cities that it requires less inspection, and investigation will show that this is not the case. There is no reason, either, to think that Philadelphia gets more or better inspection for money spent than other cities. Philadelphia's death rate, moreover, is very high, over sixteen (16.24) per thousand, due in part, no doubt, to lack of more extended food inspection.

There is no standardization of salaries in Philadelphia; veterinarians and lay meat inspectors receive the same compensation in spite of the difference in their training; and milk inspectors who file cards and issue licenses, who collect samples, who inspect stores, and who inspect pasteurizing plants, all receive the same salaries, although these are different grades of work. Moreover, a man who has been employed only one month receives just as much as one who has spent his life in the service. A good inspector, alive to modern requirements, receives just as much, and just as little, as one who does just enough to escape dismissal. "As a device for killing incentive and interest, and for turning out a body of chair-warmers, a salary fixed by statute and incapable of increase for merit or of decrease for inefficiency has no equal."*

The salaries of Philadelphia milk and meat inspectors are not only not standardized, but they are also considerably lower than those of other large cities, of the State and of the Federal Government (Exhibit A).

The veterinarians especially are underpaid. Even by working overtime they cannot keep the meat situation under control, yet in order to make an adequate living it is necessary for them to engage in some outside practice. Other cities, New York, Chicago, Pittsburgh, and Boston, pay their veterinarians more than Philadelphia, $1200, $1500, $1500, $1300, respectively, and require full-time service, and yet for the last few years Pittsburgh has not been able to secure any veterinarians. Philadelphia's salary of $1000 is not sufficient compensation for the services rendered.

No allowance is made for expenses either for transportation or for postage, and this in many instances is a great drain on the inspectors' salaries. In order, therefore, to keep expenses down as much as possible, they spend a great deal of time walking from place to place. The city gains nothing, therefore, because what it saves in an expense account it loses in valuable time.

d. Office.—The average person cannot do his best work when he is subject to constant interruption and disturbance caused by loud talking and general confusion. As this is the usual state of affairs in the Food Inspection Office, the chiefs must necessarily be under a severe strain when working here, or else must absent themselves from the office when doing important work. This may result in their being away just at a time when they are most needed.

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*Andrews, John D.: *A National System of Labor Exchange:* "The New Republic," December 26, 1914.

e. Duties—Milk Inspectors.—One assistant milk inspector is assigned to the office for clerical work. The work of an inspector should be inspection, not filing and copying cards. Ordinary clerical work is of a lower grade than inspection service; this is, therefore, a case of a high-grade man doing low-grade work, and, moreover, doing it less efficiently probably than a lower-priced man trained in that kind of work.

All except certified milk must be pasteurized, and must be bottled at the pasteurizing plant, and those bottles must reach the consumer unopened. Yet after an inspector makes a physical test for specific gravity and temperature, he pours the milk back into the bottles, replaces the caps and returns the bottles to the ice-box. While the inspector's instruments are supposed to be sterilized after each test, it is often impossible for him to get boiling water. Moreover, in pouring the milk out it is contaminated by dirt on the mouth of the bottle. The cap also is not tight after once it has been removed. This practice is not fair to the purchaser who believes that he is buying an unopened bottle of milk.

In collecting samples for bacteriological examination, the inspector opens a bottle and takes a sample on the street or wherever he may happen to be. This practice allows dust and germs from the air and any dirt that may be on the mouth of the bottle to enter the milk. This is not fair to the dealer.

For over a year now, in addition to milk-handling establishments, milk inspectors have been inspecting meat stores, thus leaving the meat inspectors free to spend their entire time on abattoirs and wholesale houses. While it is a much better arrangement to have one set of inspectors do all the stores, both milk and meat, in his district, yet it is fair neither to the inspector nor to the public for the districts to remain the same size as when only milk stores were inspected. With twice as many stores to be inspected it is obvious that reinspections must necessarily occur less frequently.

If a store is unsanitary, the dealer is served with a "five-day notice," and if he does not comply with the conditions of this notice, his license is revoked. If he still continues in business he is then prosecuted for selling without a license. Markets are dealt with in the same manner as stores until licenses are revoked. Then, if it is a municipal market, nothing more is done. Both the North and South Second Street Markets are very unsanitary. They are open markets and are entirely unscreened. No licenses have been issued for them for the last three years, yet they continue to carry on business just the same. If they are to be allowed to continue they certainly should have to obtain licenses. This would net the city about $500 each year, so that in the three years in which they have been allowed to sell without licenses the city has lost $1500. If, however, the Bureau of Health so far condemns them as to refuse to grant licenses, then there is no possible excuse for its stopping there and allowing them to continue business as a menace to public health. The mere refusal to grant licenses does not relieve the Bureau of Health of responsibility in the matter of municipal markets. Its work is the protection of public health and the fact that it is the city which is at fault and not a private dealer is no excuse for negligence. The city's income in 1914 for rental of stalls in these two markets was about $17,500. They could be boarded in, screened, and brought up to the standard for less than this sum, yet nothing is done. It is clearly up to the Bureau of Health to force this issue.

The practice of allowing inspectors to follow their own inclination in doing their work is not commendable. While in some cases good results may be obtained by assigning an inspector to a district with instructions to "clean it up," yet in other cases just the opposite may occur. It gives the inspectors liberty which may prove an irresistible temptation to some of them. The supervisors should be familiar enough with the inspection districts and the work to outline the daily routine of their assistants. If an inspector were needed during the day he could then be reached in a short time either by telephone or by messenger, whereas now it is practically impossible to communicate with him. If a daily outline were used it would be a very easy matter also to see whether or not the inspectors were "on the job," while now this is next to impossible.

f. Duties—Meat Inspectors.—Four veterinarians are supposed to oversee all slaughtering that goes on in sixty-eight (68) abattoirs. This is an average of seventeen (17) per man, an impossible number. Practically all of the abattoirs slaughter several hours each day and so an inspector cannot possibly be present at more than three or four a day during slaughter. The other establishments are supposed to leave the entrails of all animals attached to the carcasses until after the inspector has examined them. There is, however, plenty of opportunity for a dishonest dealer to get rid of suspicious carcasses before the inspector arrives. The animals that are known to be diseased, moreover, are not sent to the large federal-inspected plants, or to plants where a city inspector is likely to be on duty. These animals for the most part go to the small, practically uninspected, slaughter houses.

g. Hours of Work.—If time records are to be kept at all they should be kept by every inspector; there is no reason why three or four should be excused. If there were more supervision of the records this could not pass unnoted. If these records were checked up occasionally this fact would come to light, also the fact that some of the inspectors are not putting in the required number of hours. Some over-zealous or very much interested workers may put in more than the required time, but this will not make up for deficiencies of other inspectors. If the city is paying a man for forty hours a week it deserves and should demand forty hours of his time.

To be of value the records must be accurate. If an inspector spends seven hours and twenty minutes on his work, his time report should show this and not eight hours. Unless weekly and monthly totals are desired there is no use in leaving space for them on the report card. If they are needed the inspectors should be required to put them in or arrangements be made for an office clerk to do all totaling.

Indefinite working hours are very undesirable from the point of view of the employer, not always from that of the employee. While in the case of meat inspectors this may not be abused, still as a practice it is objectionable. They should have definite working hours and should be required to keep time records as a check on their work. Although when the Division of Meat Inspection was first established it was not thought necessary to engage veterinarians for full time, the work of the service has increased to such an extent that this should now be done. It seems to be merely an understanding in the force, moreover, that this part-time service exists, as no definite written statement of the fact can be found.

h. Work Records.—The daily work records kept by meat inspectors are too brief and incomplete to be of much value to the division.

The weekly record blanks used by the meat inspectors are large and cumbersome. Using a long sheet of paper is undesirable; it must be folded, and so is hard to file in an easily accessible manner.

In order to be of value to the service, the catalog of dealers and the farmers from whom they receive their milk must be kept up to date.

According to the records, work on dairy farms must have been very much neglected from 1907 to 1912. One hundred (100) inspection visits in five years, or twenty per year, is hardly a satisfactory record. Fortunately, this was corrected in 1912 and actual inspection begun.

Stores should be scored on every visit. It makes more impression on the dealer if a card is made out than if the inspector merely looks around a little, makes one or two suggestions, and leaves. If a card is left showing the shortcomings of the shop the dealer is more likely to correct them than if he has just received verbal orders to do so. There is, moreover, considerable educational value attached to this system. These cards would also serve as a good check on the inspectors' work. A carbon copy should be made of each inspection and at the close of the day these should be mailed to the office at the expense of the city. If the men received munificent salaries they might be expected to pay the postage, but out of $1,020 a year the city can hardly expect a man to spend five or six cents a day for postage. The work of the Service is very much hampered and its efficiency reduced because of lack of funds.

Better control over the milk trade would be established if licenses were issued each year rather than once a lifetime. Since the first milk license was issued in 1910, over 2,600 inactive licenses have accrued. At any time these may be revived and the business opened up again unknown to the Bureau of Health.

The present method of using the same printed form for different kinds of licenses is unbusinesslike and also extremely misleading to dealers, who often, especially among the foreign element, do not understand that one license does not give them the right to do everything mentioned on the face of that license. The use of a rubber stamp is undesirable also, as the ink often fades and at a distance of two or three feet no one can tell what the license is for.

i. Inspection Districts.—With twice as many stores to be inspected it is obvious that reinspections must necessarily occur less frequently. Conditions were not good enough to warrant this reduction. It is a much better arrangement to have one inspector do all the stores in his district, but in such case the districts should be smaller.

j. Inspection.—Much of the effectiveness of inspection at slaughter in the city is lost because meat from various parts of the state is allowed to enter the city with little or no inspection. Disease often cannot be detected in dressed meats, so little is accomplished by inspecting market trains. This meat should not be admitted unless it has been under adequate supervision at slaughter. Unless, moreover, there is a regular authorized "Farmers' Exemption," farmers should not be allowed to sell uninspected meat in the city. Otherwise, meat from animals which were so badly diseased that they could not be sold at a stock-yard or killed at an inspected slaughter may easily be placed on the market.

k. Complaints.—Anonymous complaints really deserve no attention. They are investigated, however, in the course of time, because in this way some violation of Rules and Regulations may be discovered which ordinarily might escape notice. If, however, people could be persuaded to sign their complaints they would receive immediate attention and so be much more effective.

One of the inspectors accompanied by an investigator worked in a more or less inefficient manner. He was very courteous and pleasant in all the stores, but seemed to work without method, stopping in some stores but not in others, and looking around a bit, but evidently with no special plan of investigation in mind. He made no record whatever of the investigation. Little can be accomplished by work of this kind.

l. Instruction of New Inspectors.—While a man about to engage in milk and meat inspection work needs some practical training, still this should not be the only kind that he is given. A thorough knowledge of the Rules and Regulations governing the sale of milk and meat should be one of the first requirements of office. Unless an inspector knows the rules, as in some instances those accompanied evidently did not, he cannot be sure whether or not dealers are violating them. He should know, also, the penalties attached to violations of the rules and not, as one inspector did, say that "to have unwholesome food in possession with intent to sell, to expose for sale, and to sell" comprises three separate offenses and makes the dealer liable for three separate fines.

m. Supervision.—More efficient supervision is necessary. This cannot be attained without grading salaries or appointing an office force. As it is, the chief inspectors have to attend both to the office work and to supervising field work. This is making too great a demand on the chiefs and naturally results in inadequate supervision both in office and in field work.

n. Bacteriological and Chemical Examinations of Milk.—While bacteriological examination and subsequent notices sent out keep the bacteria count down fairly well, more efficient control could be obtained if the results were made public.

Dealers would try harder to keep the count low if they knew that their customers were likely to see comparative bacteria counts of milk of various dealers. This would institute a wholesome rivalry for good milk among the dealers and would insure clean milk from the dairymen, as a dealer would not run the risk of losing his customers by buying dirty milk.

Numerous cities today are publishing bacteria counts with the result that their low-grade milk is now sent to cities which do not publish results of examinations. Moreover, this is mandatory upon the Board of Health by Section 9, c., 300–23, September, 1890.

o. Punitive Measures Taken.—The policy of the Service to use tact, reason, and patience in an effort to remedy conditions gradually rather than to use force is estimable. It is much better to secure a cordial observance of the law by square, open dealing, consultation and persuasion, than by wholesale prosecutions to bring to punishment only such law breakers as can be caught in the act.

The practice, however, of issuing "five-day notices" and then giving dealers two or three months to comply with them is questionable. The length of time for which the notice is issued should be suited to the changes to be made. Five days is long enough to give a man to clean up his place. but it would in all probability take him considerably longer than that to install a pasteurizing apparatus. The notices lose their effectiveness by making unreasonable demands which have to be retracted.

C. CONSTRUCTIVE SUGGESTIONS

1. MUNICIPAL INSPECTION SERVICE

a. Growth of Food Inspection.—The increase in the amount of work in the Milk Inspection Service since 1904, due to increased consumption, to bottling and pasteurization of milk, warrants an increase in the inspection force.

With the present demands, owing to increased knowledge of the dangers from infected meat, and with the present numerous poorly equipped abattoirs scattered about the city, more veterinarians are absolutely essential. If fewer licenses were granted and all butchers required to bring their cattle to four or five large abattoirs conveniently located, it would be possible to inspect all cattle at slaughter with only a slight increase in force.

b. Extent of Control.—The city should have control over more than just milk and meat. Foods offered for sale outside should be kept in glass cases. Inside, all foods except vegetables should be screened or covered with glass. In this way food would be protected not only from dust and flies, but also from handling by prospective buyers. It is highly desirable to have each loaf of bread wrapped in paraffin paper at the bakery.

Hotels and restaurants need inspection and this work should be done by the city Food Inspection Service. This highly important field has already been neglected too long.

The state has recently decided to assume control of bakeries, but as yet nothing has been done. Unless adequate supervision is instituted by state officials the city should take over the work.

Naturally an increase in force would be necessary to cover this field of activities. The Division of Food Inspection as proposed should then consist of a chief of the division, assisted by a chief meat inspector, chief milk inspector, chief inspector of general foodstuffs, and a chief clerk, together with veterinary inspectors, an inspector of wholesale meat markets, a fish expert and an inspector of preparing plants and chicken slaughter houses; an inspector of pasteurizing plants, inspectors of wagons and platforms, an inspector of dairies, and a collector of bacteriological and chemical samples; inspectors of stores and eating places and collectors of samples; a stenographer and a file clerk.

c. Organization and Expenditures.—Milk and Meat and Cattle Inspection Service should be combined to form one Division of Food Inspection and a Chief of the Division should be appointed. The chief milk inspector and the chief meat inspector would then be relieved of office duty and could devote practically all of their time to supervising and checking up the work of their assistants.

The service should have an office force consisting of a chief clerk, stenographer, and file clerk. Its efficiency would be greatly increased by such an arrangement.

Philadelphia in her expenditures for food inspection compares most unfavorably with other large cities, viz.:

New York	whose per capita expenditure is	$.03
Baltimore	“ “ “ “ “	.05
Chicago	“ “ “ “ “	.05½
Boston	“ “ “ “ “	.07
Pittsburgh	“ “ “ “ “	.10
PHILADELPHIA	“ “ “ “ “	.01½

If Philadelphia were to pay five (5) cents per person for food inspection, less than these other cities average, the total appropriation would be $82,500 as compared with the present $27,352. For this amount adequate supervision and protection of our food supply could be secured. Are not Philadelphians, residents of the third largest city in the United States, willing to pay five (5) cents each for the protection of their health from infected and poisonous foods?

There should be a standardization of salaries of milk and meat inspectors based upon grade of work and length of service. This would make the positions more attractive and also would be an incentive to better work. While the present salary is sufficient for beginners, there should be some possible increase for continued service, and certain positions requiring more technical knowledge should be more adequately provided for.

The city service should attract and hold the best of its citizens. It cannot do this unless it offers a fair compensation for services rendered. Philadelphia ought to pay its inspectors in accordance with their duties and responsibilities.

Veterinarians especially should be paid considerably more than at present.

Allowance should be made for postage and car-fare. It would be of considerable advantage for the Service to have two or three automobiles, one for collecting samples, one for dairies, and one for inspecting pasteurizing plants. The increase in the work accomplished would doubtless compensate for the added expense. That the food inspection service of a city of the size of Philadelphia is not using automobiles seems perfectly absurd when the large area which is covered by the city is taken into consideration.

d. Office.—The present office is large enough to meet the needs of the service, but it should be subdivided completely into several smaller rooms or else the Service should be moved to different quarters. Each chief should have a private office where he would not be disturbed constantly by the routine work of the service. There should also be a reception room and a large room for general office work.

e. Duties—Milk Inspectors.—All inspectors should be assigned to inspection service and clerks supplied to do clerical work.

The city should make an appropriation out of which to buy samples of milk for testing.

Unopened bottles of milk should be collected for bacteriological examination, and the city should pay for the milk which it collects.

Since the work of the milk inspectors has been greatly increased by taking over the inspection of meat stores, the city should be mapped out over again into smaller districts and more inspectors should be appointed to take charge of the extra districts.

If an automobile were purchased for use in inspecting pasteurizing plants, one man could take charge of all this work, thus leaving the second inspector free to inspect stores. Also, if the service had an office force, the inspector assigned to clerical duty could do field work. This would give two extra inspectors for regular inspection work.

The city markets ought to be improved immediately. Since the Bureau of Health cannot prosecute the Bureau of City Property, it should institute proceedings against the individual dealers renting stalls in the markets.

This would force the issue. It is clearly up to the city either to close its markets or to bring them up to the standard which it requires in privately owned establishments. But the people in the districts in which the municipal markets are located appear to depend almost entirely on them for their meat supply. Many of these people, moreover, are quite poor, and they can procure meat cheaper at the municipal markets than at the stores. To close the markets, therefore, would be a great hardship to such people, as well as a loss to those who can least afford it. But something must be done. Philadelphia, like other large cities, should provide its citizens with adequate modern market facilities.

The chief inspectors should plan the daily work of the assistants. Each man then would have a definite outline of his work, together with an apportionment of his time, so that if he were wanted during the day, the office would have little trouble in reaching him. This method has been tried in many cities and has proved to be an efficient check on the inspectors' work.

f. Duties—Meat Inspectors.—There should be either fewer slaughter houses or more veterinary inspectors. No slaughtering should be permitted in the absence of an inspector, and a separate compartment should be provided in each abattoir where the inspector could keep suspected meat pending more careful examination. The inspector only should have access to this room.

If the city would license only four or five slaughter houses or would establish four or five municipal abattoirs and require all slaughter to be done there, the present force of four veterinarians and chief would need to be increased by only one or two. One inspector could then be on duty in each abattoir all day, and there would be an additional one to assist and to act as substitute in the absence of one of the others.

Municipal slaughter houses are recommended by both state and federal authorities. Better and more complete control of the meat situation can be obtained and maintained in this way, "and it has been shown in a majority of cities abroad and in other states that such abattoirs can be run even at a profit to the city and still with less expense to those who are engaged in the business than is possible under the present plan."*

g. Hours of Work.—All inspectors should be required to keep time records. These should be examined at the end of each period and if incorrect or incomplete, should be handed back to the inspectors for completion and correction. If they show that the inspector is not putting in full time, an explanation should be required, and if no adequate excuse is given, he should be reprimanded.

Work and time reports must be accurate to be of value. Weekly and monthly totals should be put in either by the inspector himself or by a clerk. If there were a regular office force this could well be left to the filing clerk and so save the inspectors' time.

The veterinary inspectors should have definite working hours and should keep time reports. They should also be employed definitely for full time.

h. Work Records.—More complete daily report blanks should be supplied for the veterinary and lay meat inspectors (Exhibits K and L); and new monthly summary report blanks of the same size as those kept by milk inspectors should be kept by the meat inspectors (Exhibit M).

The catalog of dealers and the farmers from whom they receive their milk should be brought up to date and then checked up every few months and changes noted on the cards. If the service had a proper office force, this would not be a great tax on the inspectors' time.

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* *Annual Report of the State Livestock Sanitary Board*, 1913, page 4.

The appropriation to the service should be large enough to provide a sufficient number of score cards so that stores could be scored on every inspection visit. A direct appropriation for the necessary postage should be made to the service also.

A new bill should be presented to the legislature to provide for expiration and renewal of milk licenses.

Either different printed forms should be used for licenses to sell different products and to conduct slaughter houses and preparing plants, or space should be left at the proper place and a special type machine used to write in just what the licensee is authorized to do.

i. Inspection Districts.—Since the work of the milk inspectors has been greatly increased, the city should be mapped out over again into smaller districts and more inspectors should be appointed to take charge of the extra districts.

j. Inspection.—Absolutely all meat sold in the city should be inspected at slaughter by competent authorities. So long as any is uninspected, the health of the community is endangered, for the unscrupulous dealer then has an opportunity to dispose of diseased animals.

k. Complaints.—The public should be instructed to sign their complaints about dealers in order that they may receive immediate attention.

If the inspectors' work were planned for them and they were required to follow these daily outlines rigidly, there would be no such haphazard work as that performed by one inspector, accompanied. If, moreover, score cards were filled out on every visit the inspector's work would be more effective and the score cards could be used as a check upon his work.

l. Instruction of New Inspectors.—The service should prepare a Manual of Instruction for new inspectors, comprising rules and regulations, methods of making tests, instructions as to office procedure, time and work records, etc.

m. Supervision.—Salaries should be standardized and two or three of the men appointed supervisors, or else an office force should be appointed to take charge of the office and clerical work and thus leave the chief inspectors free to devote a large portion of their time to supervision.

n. Bacteriological and Chemical Examinations of Milk.—The results of milk examinations should be published. Failure to do this is a direct violation of Section 9, Ordinance 300. The names of the producers should be published, together with those of the persons in possession of the milk at the time the samples were taken. Space for such publication could be allotted in the monthly bulletin of the Department of Public Health and Charities.

o. Punitive Measures Taken.—If a "five-day notice" is issued, only five days should be given for compliance with that notice. Other notices, however, should be issued if more time is needed, stating specifically just how much time will be granted for the required improvement.

EXHIBITS

A. Comparison of Expenditures for Food Inspection—1914.—Comparison of Salaries of Inspectors.
B. Comparison of Hours of Work of Milk Inspectors.
C. Division of Milk Inspection.—Increase in Force and in Number of Inspections, 1889–1914.
D. Division of Meat and Cattle Inspection.—Increase in Force and in Number of Inspections, 1904–1914.
E. Cities in Order of Expenditures for Food Inspection in 1914 and their Populations.
   Cities in Order of Population and Amounts Expended for Food Inspection in 1914.
F. Cities in Order of Per Capita Expenditures for Food Inspection in 1914.
   Cities in Order of Population, and Per Capita Expenditures for Food Inspection in 1914.
G. Food Inspection in Philadelphia.
H. Food Inspection Service—Present Organization.
J. Division of Food Inspection—Proposed Organization.
K. Milk Inspection Districts.
L. Meat Inspection Districts.

EXHIBIT A

COMPARISON OF EXPENDITURES FOR FOOD INSPECTION—1914

Cities	Population	Total Expenditures	Per Capita Expenditures
Pittsburgh	600,000	$59,973	$.0999
Boston	733,562	53,234	.0726
Chicago	2,393,325	124,460	.0562
Baltimore	578,000	28,980	.0501
New York	5,500,000	173,730	.0316
Philadelphia	1,650,000	27,352	.0166

COMPARISON OF SALARIES OF INSPECTORS

	Veterinarians	Milk and Food Inspectors
United States	$1400–1800	$1800–2000
Pennsylvania	1800–2000	1500
Chicago	1500	1200–1440
Pittsburgh	1500*	1080
Boston	1300	1200
New York	1200	1200–1800
Baltimore	..	1080 (milk) 900 (food)
Philadelphia	1000	1020

* Offered, but can get no veterinarian for this.

EXHIBIT B

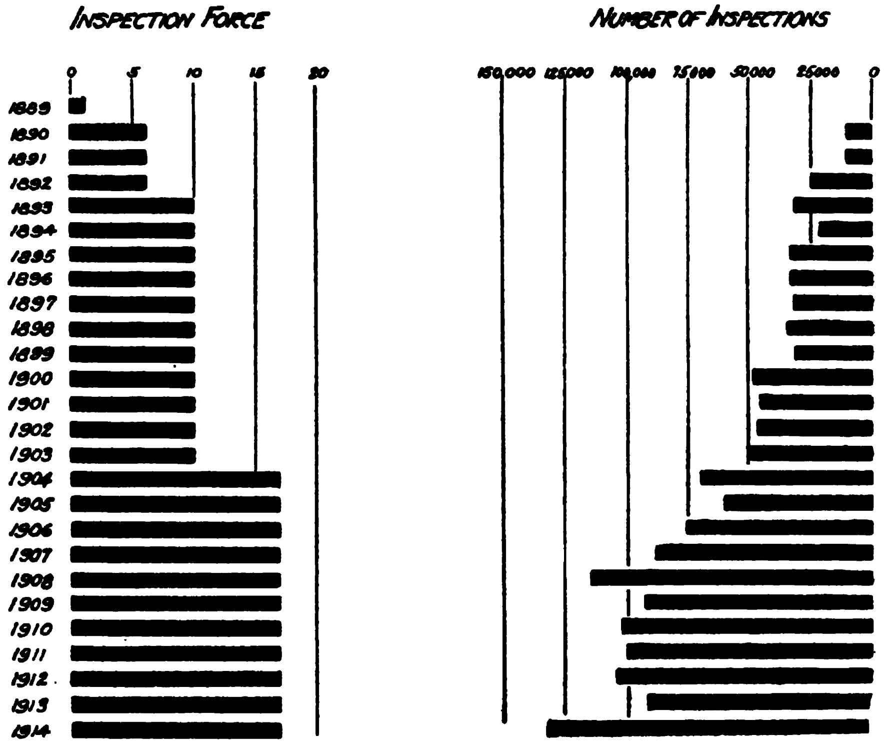
COMPARISON OF HOURS OF WORK OF MILK INSPECTORS

Inspector	July					November				
	Average Time per Week		Total Time of Work		Number of Working Days	Average Time per Week		Total Time of Work		Number of Working Days
	Hours	Minutes	Hours	Minutes		Hours	Minutes	Hours	Minutes	
A	38	24	192	..	30	39	10	150	..	23
B	45	20	204	..	37	45	35	214	..	28
C	39	7	176	..	37	44	39	171	..	23
D	35	3	151	45	26	46	13	177	..	23
E	48	16	208	..	26	44	39	171	..	23
F	..	..	..	..	..	..	..	..	..	..
G	45	49	206	10	27	45	24	136	10	18
H	..	..	..	..	..	44	54	172	..	23
J	39	8	156	30	24	45	15	181	..	24
K	39	26	138	..	21	43	52	168	..	23
L	45	56	183	45	24	46	49	132	30	17
M	40	26	181	55	27	45	16	310	55	28
N	..	..	..	..	..	..	..	..	..	..
P	37	16	167	43	27	37	51	176	25	28
Q	46	30	209	15	27	56	55	218	..	23
R	..	..	..	..	..	..	..	..	..	..
Total	41	36	2146	3	313	45	..	2278	5	304

Note: Inspector's names are not given, as this is not a criticism of individuals but of service.

-EXHIBIT-C.

DIVISION OF MILK INSPECTION
INCREASE IN FORCE AND IN NUMBER OF INSPECTIONS
1889-1914



Bureau of Municipal Research of Philadelphia
[illegible]

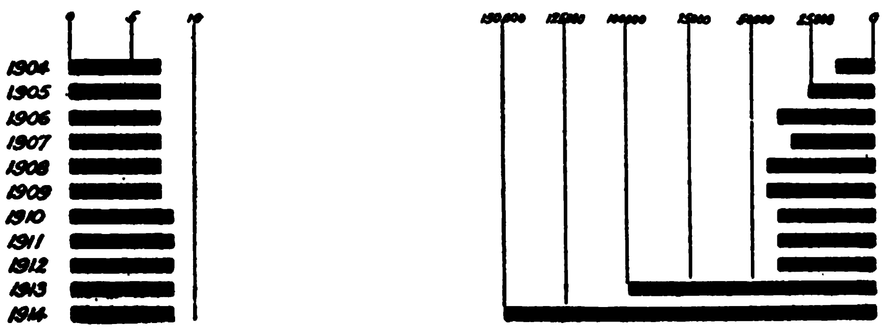
EXHIBIT-D

DIVISION OF MEAT AND CATTLE INSPECTION
INCREASE IN FORCE AND IN NUMBER OF INSPECTIONS

1904-1914

INSPECTION FORCE

NUMBER OF INSPECTIONS

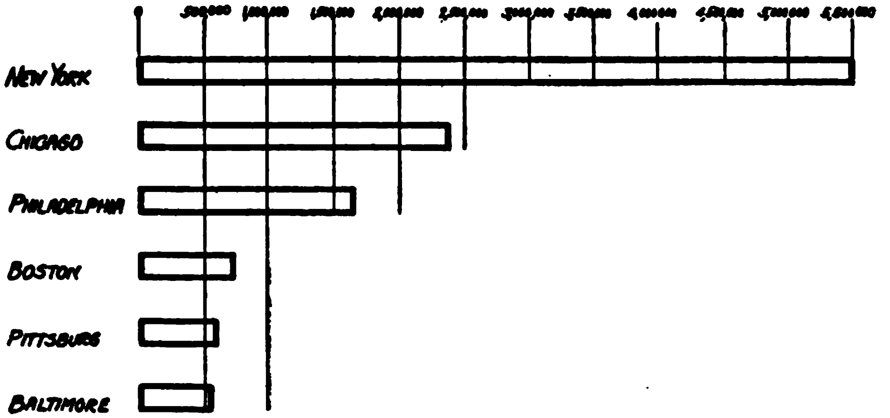


BUREAU OF MUNICIPAL RESEARCH OF PHILADELPHIA

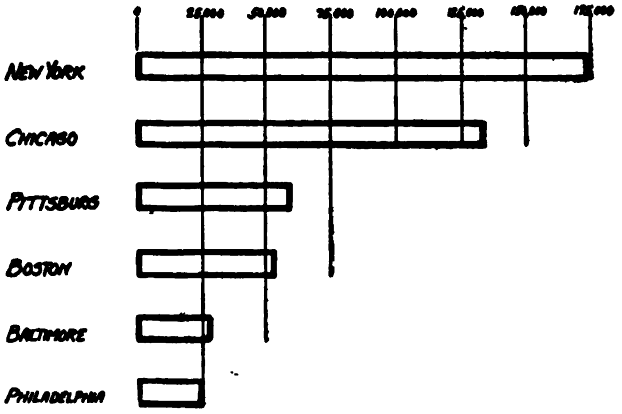
EXHIBIT - E

Comparison of Six of the Largest Cities of the United States as to Population and Expenditures for Food Inspection in 1914
(Figures from St. Louis, Cleveland and Detroit not Obtainable)

Comparison of Population



Comparison of Expenditures for Food Inspection



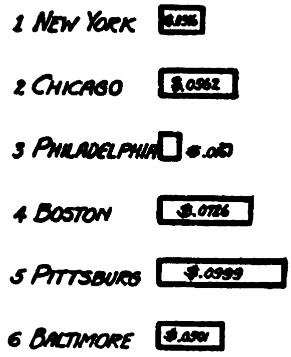
Bureau of Municipal Research of Philadelphia
1916 [illegible]

EXHIBIT – F

COMPARISON OF SIX OF THE LARGEST CITIES OF THE UNITED STATES AS TO POPULATION AND PER CAPITA EXPENDITURES FOR FOOD INSPECTION IN 1914

(FIGURES FOR ST. LOUIS, CLEVELAND AND DETROIT NOT OBTAINABLE)

PER CAPITA EXPENDITURES OF CITIES, ARRANGED ACCORDING TO POPULATION



CITIES ARRANGED ACCORDING TO PER CAPITA EXPENDITURES

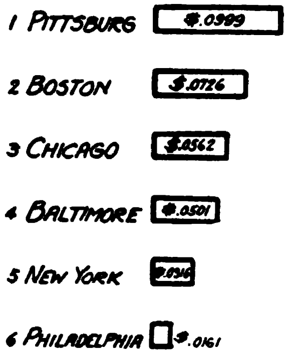


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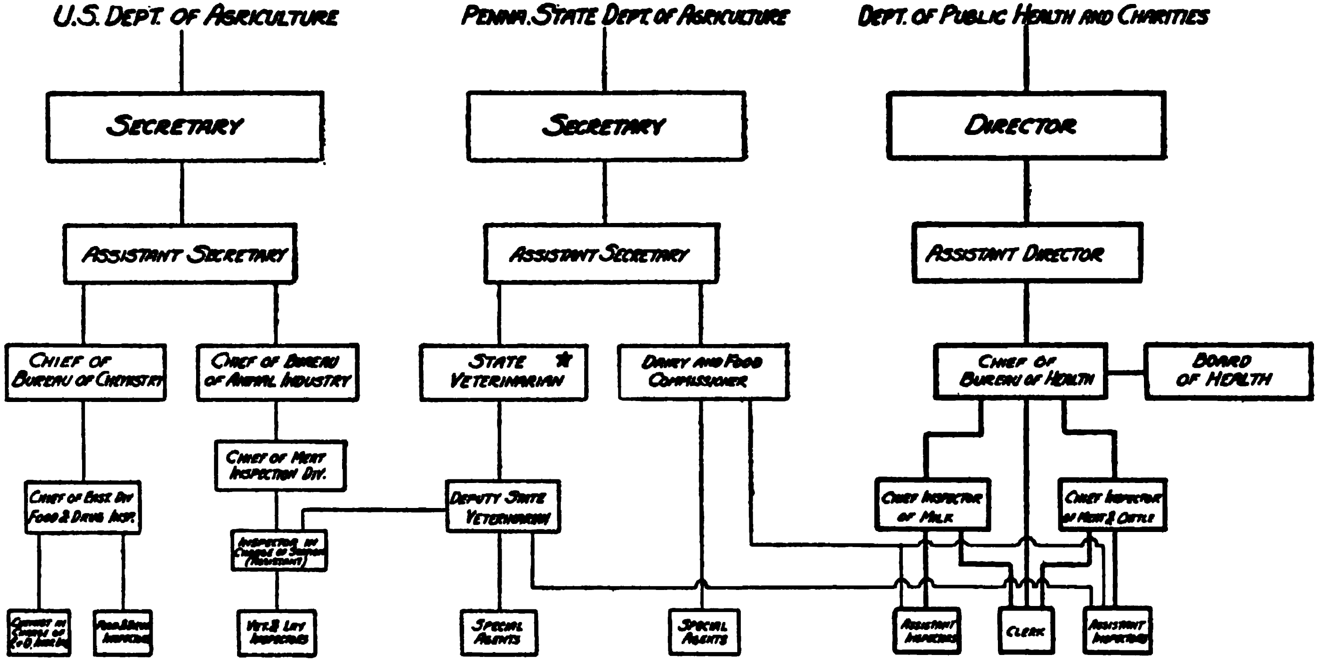
EXHIBIT-G

FOOD INSPECTION SERVICE IN PHILADELPHIA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CHIEF OF BUREAU OF CHEMISTRY
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INSPECTOR IN CHARGE OF STATION (ASSISTANT)
CHEMIST IN CHARGE OF F.& D. INSP. LAB.
FOOD & DRUG INSPECTORS
VET. & LAY INSPECTORS
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DAIRY AND FOOD COMMISSIONER
DEPUTY STATE VETERINARIAN
SPECIAL AGENTS
SPECIAL AGENTS
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CHIEF INSPECTOR OF MEAT & CATTLE
ASSISTANT INSPECTORS
CLERK
ASSISTANT INSPECTORS

★ EX-OFFICIO MEMBER OF THE STATE LIVESTOCK SANITARY BOARD

EXHIBIT H

MUNICIPAL FOOD INSPECTION SERVICE-(PRESENT ORGANIZATION)

DEPARTMENT OF PUBLIC HEALTH AND CHARITIES

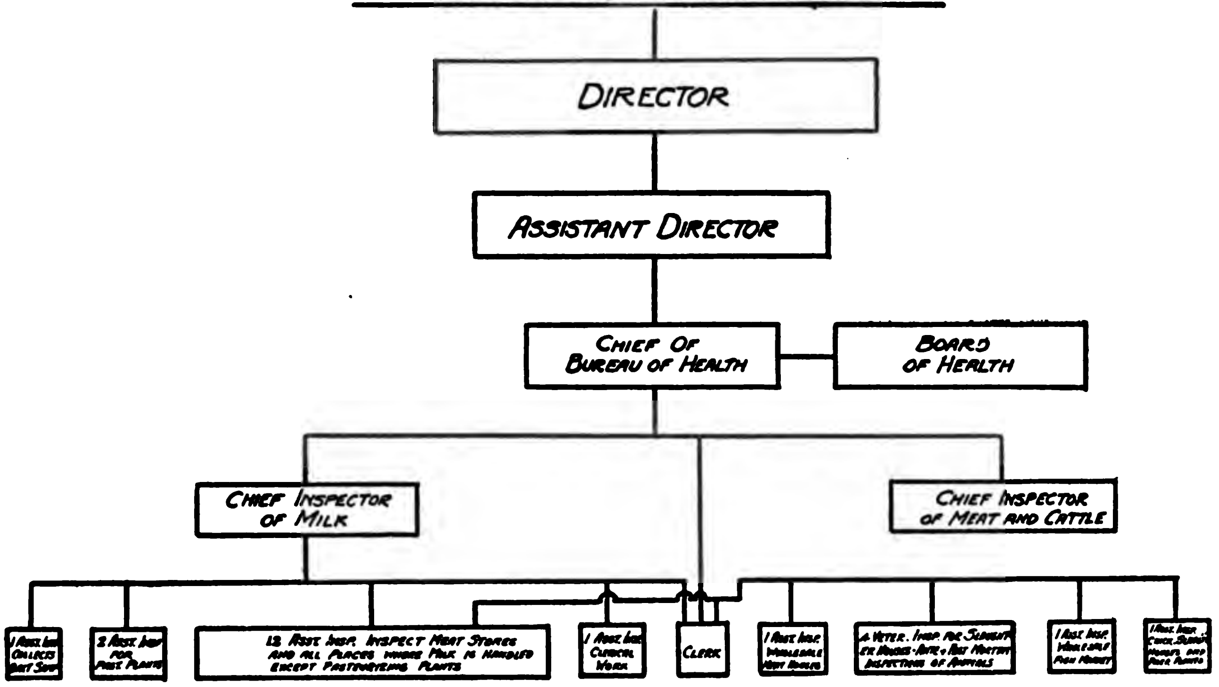
DIRECTOR
ASSISTANT DIRECTOR
CHIEF OF BUREAU OF HEALTH
BOARD OF HEALTH
CHIEF INSPECTOR OF MILK
CHIEF INSPECTOR OF MEAT AND CATTLE
1 ASST. INSP. COLLECTS BACT. SAMP.
2 ASST. INSP. FOR PAST. PLANTS
12 ASST. INSP. INSPECT MEAT STORES AND ALL PLACES WHERE MILK IS HANDLED EXCEPT PASTEURIZING PLANTS
1 ASST. INSP. CLERICAL WORK
CLERK
1 ASST. INSP. WHOLESALE MEAT HOUSES
4 VETER. INSP. FOR SLAUGHTER HOUSES - ANTE & POST MORTEM INSPECTIONS OF ANIMALS
1 ASST. INSP. WHOLESALE FISH MARKET
1 ASST. INSP. STOCK SLAUGHTER HOUSES AND PORK PLANTS

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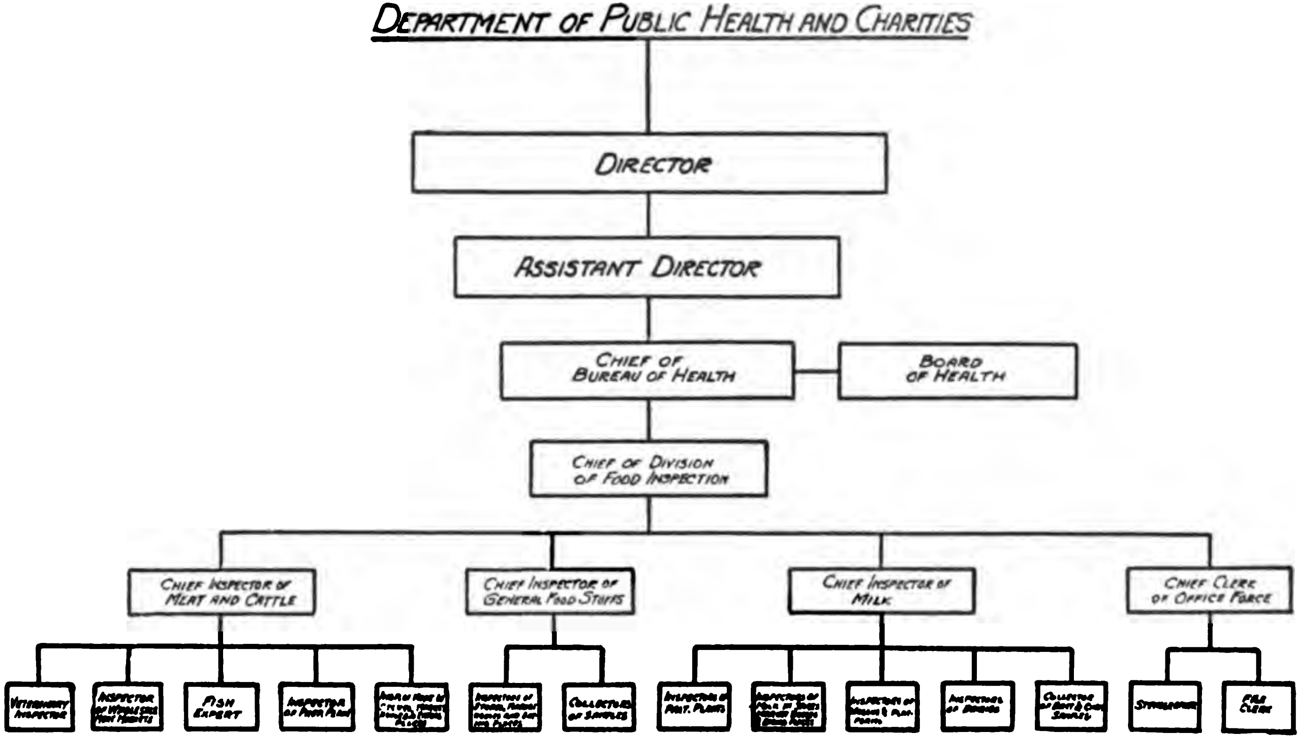
EXHIBIT-J

MUNICIPAL DIVISION OF FOOD INSPECTION-PROPOSED ORGANIZATION


DEPARTMENT OF PUBLIC HEALTH AND CHARITIES
DIRECTOR
ASSISTANT DIRECTOR
CHIEF OF BUREAU OF HEALTH
BOARD OF HEALTH
CHIEF OF DIVISION OF FOOD INSPECTION
CHIEF INSPECTOR OF MEAT AND CATTLE
CHIEF INSPECTOR OF GENERAL FOOD STUFFS
CHIEF INSPECTOR OF MILK
CHIEF CLERK OF OFFICE FORCE
VETERINARY INSPECTOR
INSPECTOR OF WHOLESALE MEAT MARKETS
FISH EXPERT
COLLECTORS OF SAMPLES
INSPECTORS OF PAST. PLANTS
STENOGRAPHER
FILE CLERK

Bureau of Municipal Research of Philadelphia

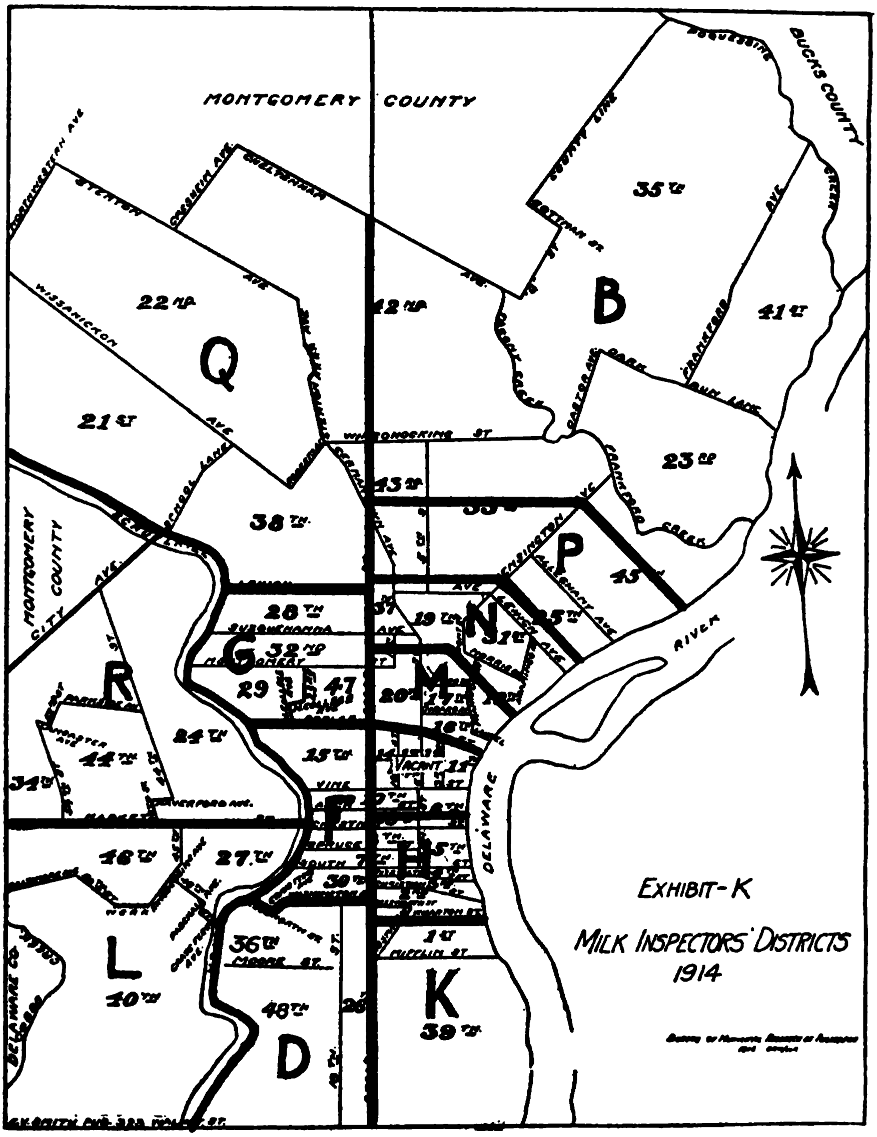


EXHIBIT-K

MILK INSPECTORS' DISTRICTS 1914

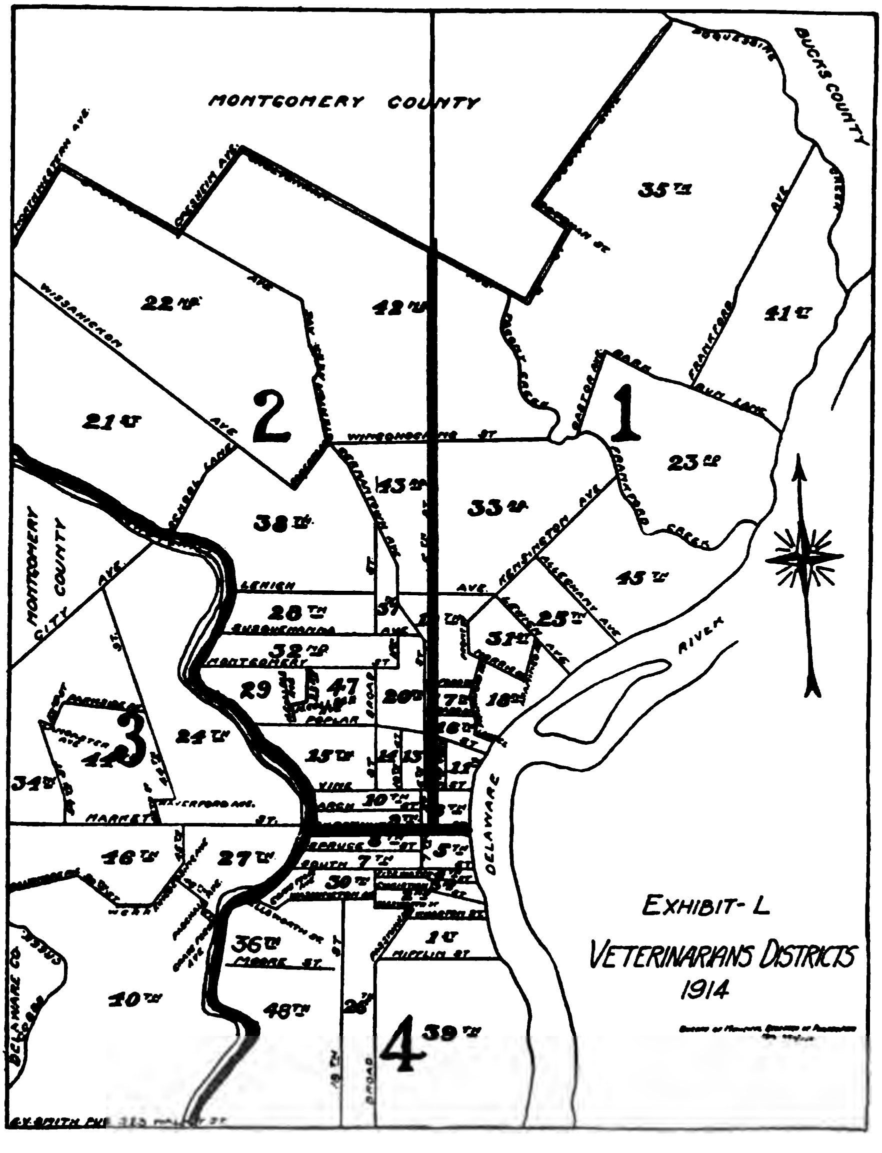


EXHIBIT-L

VETERINARIANS DISTRICTS 1914

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UNIVERSITY OF PENNSYLVANIA

THIRTEENTH REPORT

OF THE

HENRY PHIPPS INSTITUTE

FOR THE STUDY, TREATMENT, AND PREVENTION OF TUBERCULOSIS

PUBLISHED BY THE
HENRY PHIPPS INSTITUTE
SEVENTH AND LOMBARD STREETS
PHILADELPHIA
1917

UNIVERSITY OF PENNSYLVANIA

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Reprinted from the Transactions of the Association of American Physicians, 1916

A STUDY OF THE DIET IN DISPENSARY PATIENTS[1]

By FRANK A. CRAIG, M.D.

AND

H. R. M. LANDIS, M.D.

PHILADELPHIA

In the study of any disease it is extremely important to determine not only the direct, immediate mode of infection, but also to carefully consider all the factors which may predispose the individual to the infection. This is peculiarly true in the study of tuberculosis which apparently requires for its growth and development a lowering of the resistance of the individual. This decrease in the resistance may be brought about by some other disease, dissipation, injury, or may result from a lowering of the general vitality resulting from hard work or faulty mode of living. Every plan suggested for the eradication of this disease must be considered incomplete and ineffectual which does not recognize the importance of these contributory or predisposing factors and include in its scheme some provision for their correction or suppression.

Tuberculosis has been shown to be so preëminently a disease of the home, it is but natural that the correction of housing conditions should have attracted the attention of the numerous workers in the crusade against this disease, almost to the exclusion of other possible errors in living.

In the prevention of this disease it must be appreciated that sufficient nutriment is equally as important as sufficient fresh air and rest, as has long been recognized in the treatment of the condition. The treatment of the disease in a large measure consists in the carrying out of the methods of prevention to a greater degree than can usually be obtained in the ordinary case.

---

[1] Based on material collected by the Social Service Department of the Henry Phipps Institute, University of Pennsylvania, Philadelphia, under the Direction of Miss Lucinda Stringer.

The predisposing factors which have received the greater share of attention have been the working and housing conditions of the people, the public having been instructed in the importance of fresh air and sufficient rest and warned against the danger of dissipation, all being dealt with in considerable detail. While attention has frequently been called to the importance of the proper food, in sufficient quantity and properly prepared, ignorance of the actual conditions existing has prevented the consideration of this subject in that degree of detail which its importance demands. Too frequently the entire subject is dismissed with a few vaguely general remarks.

One of the principal reasons why this subject has not received more attention undoubtedly lies in the fact that the food supply of a community is so extremely important and presents such a stupendous problem, involving such enormous economic factors, that its magnitude alone tends to discourage interference.

METHOD OF INVESTIGATION. With the object of throwing some light upon the subject of nutrition, the Henry Phipps Institute in the early spring of 1915 started a study of the dietaries of twelve families. The study was continued during 1915 and the early part of 1916, the large majority of the cases being studied in the same season of the year.

As the season of the year appeared to exert no appreciable effect upon the cost of the food, it was considered possible to disregard the date of the investigation in the consideration of the results obtained.

Three families of each of the four races most frequently encountered in the dispensary of the Institute were selected for study, namely: Russian Jewish, Italian, Polish and Negro, only those families being chosen which it was believed would coöperate with the workers from the Institute in the carrying out of the study.

The general plan of the investigation was first carefully explained to the family and their consent to give all assistance possible was obtained. A detailed report of the various social conditions was made out by the worker from the Social Service Department of the Institute, the entire field of work of the investigation being carried out by the regular staff of this department. Whatever value the present investigation may possess must be largely attributed to intelligent interest in the work displayed by the head of the Social Service of the Institute, Miss Lucinda Stringer, and the staff of nurses associated with her in that department, together with the care and patience employed in the collection of the necessary data.

A careful inventory of all food in the house was first obtained and a record made of its character, weight, and value, then for a fixed period, usually two weeks, although in a few instances longer, all food brought into the house was weighed daily and its character and cost recorded. At the conclusion of the period of investigation a second inventory was made similar to that made just before the study of the family was started. In this way it was possible to accurately determine the amount, character, and cost of the food consumed by the family during a definite period of time. It was unfortunately deemed impracticable to determine the amount of the food which was wasted, either by spoiling in preparation, by imperfect methods of preservation, or by ignorance of domestic economy.

The exact character, quantity, and cost having been determined, the caloric value of each separate article of food was computed from the tables of Atwater and Bryant.[1] The caloric value of each food represents its actual nutritive value, as allowance has been made for waste in the raw material and the available calories for each article have been carefully estimated in each particular instance. The calories used in the various studies which follow represent the actual nutritive value of the food as nearly as is possible in a study of this kind in which no analyses were made. The figures used must under the circumstances be considered approximate and not absolute.

The use of the caloric value of foodstuffs provides a convenient basis for comparing the results with those obtained in similar investigations. It will be noted that in the following tables the caloric value of the foods has been used exclusively, no reference being made whatever to the weight of the various foodstuffs. This has been considered advisable, as it eliminates all confusion caused by the difference in value between the fats and proteins and carbohydrates. In computing the caloric value of the various foodstuffs the protein and carbohydrates have been reckoned on a basis of four calories to the gram, and fats on a basis of nine calories to the gram.

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[1] The Chemical Composition of American Food Materials, U. S. Department of Agriculture, Bulletin No. 28, revised edition.

The study of a dietary cannot be confined to a study of the caloric value alone, there being other factors involved which affect the amount of actual nourishment derived from the food or influence the amount consumed. It is unfortunate that these factors are extremely difficult to estimate and even more difficult to express, and yet there can be no question that the flavor of the food, its digestibility, the selection of a proper variety, and the methods used for its preservation and preparation are quite as important as the actual caloric value of the food selected. It is not uncommon, however, to find reports based entirely upon the caloric value, the other factors being completely ignored.

In the present study the difficulty encountered in evolving a method of concisely expressing these factors in such a manner that the results might be compared with those obtained in similar studies has practically confined the study to the caloric value of the foods. The comparatively meager reference to the other factors must not be construed as in any way minimizing their importance.

A study of the food supply of a certain portion of the community must necessarily first take into consideration the estimation of the amount of nourishment ordinarily obtained, and the determination of whether this amount is sufficient for the proper nutrition of the individuals studied. If the amount is found to be insufficient the next step would naturally consist in an attempt to discover whether the lack of nourishment was due to the fact that the people were unable to purchase a sufficient quantity of food, or due to an improper selection of food materials through ignorance. If the first cause mentioned is correct economic factors are involved which are entirely outside the scope of the present study. If, on the other hand, the second is the reason for a food supply of insufficient caloric value there is the possibility that considerable improvement might be made in the dietaries of the poor by means of education.

The actual caloric requirements of an individual or group of individuals appears to be an extremely difficult matter to determine accurately, the number of calories required by the individual in the twenty-four hours varying with the authority consulted. It is only natural that this diversity of opinion should exist when one considers that one is dealing with organisms which vary greatly in their ability to digest, absorb and utilize the food consumed. Another factor of the greatest importance is that the necessary intake of food is chiefly determined by the amount of movement and the extent of physical labor undertaken by the individual. The differences due to size and weight, age and sex, being more important from a theoretical than from a practical viewpoint.

The difficulty in determining the amount of labor actually performed by the individuals in a study like the present renders the estimation of what constitutes sufficient nourishment so extremely perplexing. For convenience the rather arbitrary standard of Atwater has been adopted in the present investigation.[1]

The total number of "men" in each family being estimated according to Atwater's scheme. Thus a family consisting of a man at hard muscular work (1.2), a woman at moderately active work (0.8), a boy of twelve years (0.7), and a girl of ten (0.6) would be reckoned as a family of 3.3 "men." If a family like that just mentioned was found to have a dietary which provided 9900 available calories daily the family would be considered as having a dietary of 3000 calories per man per day. This method of estimation is described in detail to avoid any possible confusion in regard to either the actual number of individuals in the family or the number of calories which each member of the family received daily.

Total Caloric Value of Dietaries Studied. The first point to be determined is whether the families are receiving the number of calories per "man" per day that they require for their proper nutrition. The condition found in the twelve families studied are given below, the families being designated by the small letters, a, b, c, etc., the capital letters indicating the race: I for Italian, J for Russian Jewish, P for Polish, and N for negro, these letters being used for the same families throughout the entire study.

---

[1] Principles of Nutrition and Nutritive Value of Food, U. S. Department of Agriculture, Farmers' Bulletin No. 142, page 33.

Table I.—Number of Calories Consumed per "Man" per Day by Each Family in Comparison to the Amount Required (3400)

Family.	Number of men (computed).	Calories per man per day consumed.	Caloric deficit per man per day.	Calorie excess per man per day.
I. a.	4.3	2877.0	523.0	
I. b.	7.6	2589.0	811.0	
I. c.	2.6	2605.0	795.0	
J. d.	2.4	3279.0	121.0	
J. e.	2.5	2118.0	1282.0	
J. f.	2.3	2521.0	879.0	
P. g.	2.4	2975.0	425.0	
P. h.	3.2	2997.0	403.0	
P. j.	2.9	3399.0	1.0	
N. k.	4.2	2774.0	626.0	
N. l.	3.7	2370.0	1030.0	
N.m.	2.5	3697.0	..	297.0
Total	40.6	34201.0	6896.0	297.0
Average	3.38	2850.0	549.0	

The above table shows that only one family (N. m.) out of the twelve studied was receiving more calories per man per day than the actual requirement according to Atwater, who gives 3400 calories as the requirement of a man per day. The explanation of why this one family should be receiving such a relatively high caloric dietary is probably to be found in a study of the dietary in detail, the family consuming about 300 grams of lard daily. One other family (P. j.) received practically the amount of nutrition required (3399 calories), but this family paid more for their food than any of the families studied, their food costing them $0.4118 per man per day. The ten families remaining show a deficiency in the number of calories per man per day ranging from 121 to 1282 calories, with an average deficiency of 689.5 calories per man per day. This means that ten of the twelve families studied (83 per cent.) were only receiving on an average about 80 per cent. as much food as they actually required.

The standard daily requirement for a man at moderate exercise is given by Voit as 2965 calories, which is distinctly lower than the 3400 calories as given by Atwater. When the families were studied according to Voit's figures it was found that five were receiving more than the amount required, averaging 304 calories in excess, and seven families were receiving less than the required amount, an average deficit of 414 calories. According to Voit's figures, therefore, 58.3 per cent. of the families studied were receiving only 86.1 per cent. of the required amount of nourishment.

The average deficit for the entire twelve families was 549.9 according to Atwater's figures, a deficit of approximately 16 per cent. According to Voit's figures the average deficit for the twelve families was 114.9, a deficit of 3.8 per cent.

The results based upon Atwater's figures represent more accurately the actual conditions existing. It does not seem rational to compare conditions in this country to a European standard as represented by Voit's figure.

The average number of calories per man per day in the study of these twelve families was found to be 2850 calories, a figure remarkably near the figures given by Atwater from a study of the diet of twelve laborers' families in large cities of the United States, namely, 2810, and of eleven poor families in New York City, 2845. The findings in the present study may be considered typical of the families of their class, and probably could be duplicated in almost any large city in this country.

The figures showing the lack of nutrition in the families studied merely demonstrates, in a graphic manner, what one would expect to find in studying the dietaries of the average dispensary patients. It is not surprising that ten of the twelve families studied were not receiving sufficient nutriment, but that two of them should be receiving sufficient. The reasons for these two cases receiving the large number of calories have already been given.

The families were of four races, with their peculiar customs, habits, and characteristics, and these are probably manifested to a marked degree in their selection, preparation, and purchasing of food materials. While the number of families of each race studied is too small to warrant the drawing of any very definite conclusions, the findings are at least very suggestive.

TABLE II.—AMOUNT OF NOURISHMENT AND COST ACCORDING TO RACE

Race.	Average calories per man per day for race.	Average cost per man per day for race.
Italian	2690	$0.1910
Russian Jewish	2639	.2409
Polish	3123	.3469
Negro	2947	.2215

The race receiving the largest average number of calories per man per day was the Polish, the next highest being the negro, and the Italians and Russian Jews receiving approximately the same amount. The most striking feature of the chart is found in the amounts that the different races paid per man per day for their food. The Poles received the largest number of calories and paid the most for them, the Russian Jews received the lowest number of calories and paid next to the highest for them, the Italians paying the least for their food. This point is merely referred to in passing, as this question is considered in more detail in a subsequent section dealing with the selection and purchase of food.

The fact having been established that in the families studied there existed a deficiency in the amount of nutriment, the more difficult problem presents itself of determining the cause of this lack of nourishment, whether due to poverty or ignorance. In attacking this problem the first point to be determined is whether there exists any relation between the number of calories obtained per man per day and the amount paid for the food per man per day.

The cost of food per man per day was based upon the total amount of money spent upon food during the investigation, in this sum being included the amounts spent upon condiments and beverages, such as salt, pepper, tea, coffee, etc., which did not possess any caloric value.

It was believed that if there was found to exist a definite fixed relation between the number of calories per man per day and the cost of the food per man per day, one would be justified in believing that the amount of nutriment obtained was dependent entirely upon the financial resources of the family.

In order to determine this point the families were placed in order of the number of calories obtained per man per day and the corresponding cost of food per man per day was placed opposite.

It will be seen that when the individual families are studied the relationship between calories and cost is not an absolute one. For a more general study the families were divided into four groups of three families each and the average calories and cost for each group was placed in a separate column. A study of these averages shows that the relation between calories is closer than when individual families are studied, but even here it is not absolute, as the third and fourth groups showed absolutely the same average cost while there was a difference in the average calories of slightly over 300.

TABLE III.—SHOWING RELATION BETWEEN THE CALORIES AND COST PER MAN PER DAY

Family.	Calories per man per day.	Cost per man per day including condiments and beverages.	Average calories per man per day.	Average cost per man per day.
N. m.	3697	$0.2496		
P. j.	3399	.4118	3458	$0.3218
J. d.	3279	.3041		
P. h.	2997	.3080		
P. g.	2975	.3210	2949	.2623
I. a.	2877	.1580		
N. k.	2774	.2100		
I. c.	2605	.1870	2656	.2086
I. b.	2589	.2290		
J. f.	2521	.1950		
N. l.	2370	.2070	2336	.2086
J. e.	2118	.2238		

If this relation between calories and cost was an absolute, fixed relationship the same results should be obtained by arranging the families according to the cost instead of according to calories as in the preceding table. When arranged in this manner the averages for the groups were not even as constant as in the preceding table.

One would be justified in concluding from the above that while the amount spent for food influenced the number of calories obtained to a certain extent, the number of calories obtained was not entirely dependent upon the amount spent. There appears to be some other factor involved which affects the relation between cost and calories. The only factor which could affect the result would be the nature of the food selected—in other words, the possibility of certain families obtaining more nourishment for the amount expended.

The only method which suggests itself for determining the ability of a family to select food with a high caloric value for the least amount of money is by comparing the number of calories obtained by each family for ten cents, a sum used as a standard by other writers on this subject.

The amount of nutriment obtained for ten cents varied greatly in the different families, the number of calories ranging between 884 and 1813, with an average of 1178. The question of racial influence, with its accompanying habits and customs, upon the selection of food is always extremely interesting. It will be seen that the Italians are the best purchasers, obtaining the greatest number of calories for the same sum of money. The Negroes were next to the Italians in this regard, and the Poles were the poorest purchasers of the races investigated in the present study.

TABLE IV.—SHOWING NUMBER OF CALORIES OBTAINED FOR TEN CENTS BY EACH FAMILY AND EACH RACE

Family.	Calories for $0.10 (including condiments and beverages).	Average calories for $0.10 for race.
I. a.	1813	
I. b.	1127	1443.1
I. c.	1389	
J. d.	1078	
J. e.	946	1104.9
J. f.	1290	
P. g.	926	
P. h.	970	927.2
P. j.	884	
N. k.	1317	
N. l.	1122	1238.5
N. m.	1276	
Average	1178	

The reasons why the Poles receive so little for their money, in spite of the fact that they spend the most for their food as shown by Table II, and why the Italians receive so much, can only be determined by a study of the dietaries in detail. It would appear from the study so far as if the negroes had the most evenly adjusted dietary, being second in the number of calories obtained per man per day and second in the number of calories obtained for ten cents.

The most important point to be determined is whether there exists any relation between the number of calories obtained for a certain sum and the cost of food per man per day. If this relation is found to exist, whether it is more definite and constant than the relation between the number of calories obtained per man per day and the cost of food per man per day. In other words, whether the purchasing or selecting ability influences the amount of nourishment obtained by the family to a greater extent than the amount actually expended.

In order to determine this point the families have been graded according to the number of calories obtained for ten cents, with the corresponding amount paid per man per day for food in the second column. For greater simplification the families have been grouped in series of three with the average for each group.

TABLE V.—SHOWING RELATION BETWEEN THE NUMBER OF CALORIES OBTAINED FOR TEN CENTS AND THE COST OF FOOD PER MAN PER DAY

Family.	Calories obtained for ten cents.	Cost per man per day.	Average calories obtained for $0.10.	Average cost per man per day.
I. a.	1813	$0.1580		
I. c.	1389	.1870	1506	$0.1850
N. k.	1317	.2100		
J. f.	1290	.1950		
N. m.	1276	.2496	1231	.2245
I. b.	1127	.2290		
N. l.	1122	.2050		
J. d.	1078	.5041	1056	.2723
P. h.	970	.3080		
J. e.	946	.2238		
P. g.	926	.3210	918	.3188
P. j.	884	.4118		

The foregoing table is extremely interesting because it shows that not only a definite inverse ratio exists between the number of calories obtained for ten cents and the cost of food per man per day in the average for each group, but that this also holds true of the individual families with but few exceptions.

If this relationship is exact, or approximately exact, the same results should be obtained if the families are graded according to the cost of food per man per day, and in the same manner as in the preceding table.

Graded according to the cost of food per man per day, this inverse ratio, while not as definite as in the preceding table, was found to be more exact than in those tables showing the relation between the number of calories obtained per man per day and the cost of food per man per day. In other words, the purchasing ability of the family seems to exert a more definite effect upon the amount expended for food than the amount expended for food does upon the number of calories obtained. This would indicate that the amount the family spent for food was influenced by or dependent upon the purchasing ability of the family to a much greater extent than the amount of nourishment obtained is influenced by the amount of money expended for food. One would appear justified in concluding that ignorance of the nutrient value of food was mainly responsible for the lack of nutrition, although poverty was responsible to a certain extent.

The greatest number of calories obtained for ten cents was 1813, by Family I. a. If every family studied had possessed this family's ability to select food possessing a high nutritive value for a low price, what would be the amount of nutriment obtained, supposing they continued to expend the same amount of money as before? If we take the amount of money spent daily by each family per man and note the number of calories it would provide, if they were able to obtain 1813 calories for ten cents as family I. a. was able to do, only two families would receive less than 3400 calories required and the twelve families would average 1135.9 calories more than the 3400 calories per man per day required.

The 1834 calories for ten cents was so much in excess of that obtained by any other family that this comparison seems hardly fair, and yet it shows what can be done by careful judicious purchasing and selecting of food materials. Taking the average amount expended for food $0.2502, and estimating how many calories must be obtained for ten cents to provide the 3400 necessary calories, one finds that approximately 1359 calories would have to be obtained. This number of calories for ten cents was exceeded by two families (I. a and I. c.) in the series investigated. It would seem, therefore, that 83 per cent. of the families studied were not obtaining the nutriment they should for the amount expended, and the amount they could obtain if properly instructed.

The need of educating the poor in the necessity of selecting foods of high nutritive value at a low cost appears to have been conclusively demonstrated. The possibility of obtaining food with sufficient nutriment for a slight cost has also been demonstrated by the experience of two of the families studied. The ways and means of carrying out this crusade of education presents a problem of such a wide scope that it appears impossible to attempt to even sketch it in outline in a paper of this kind. It does seem, however, that the school-houses, as community centers, might be utilized in the large cities in the carrying out of a scheme which might reach the poorer classes in sufficient numbers to warrant the expense.

In a scheme of this kind the nurse with training in public health work would be specially valuable. The necessary knowledge of food economics and dietetics together with a broad knowledge of general hygiene in the home would make them peculiarly fitted for carrying out this sort of work.

There is another factor to be considered in studying the cost of food per man per day, and that is the number of men composing the family.

The size of the family to be catered for appeared to affect the cost of the food—the larger the family, the lower the cost of food per man per day up to a family of less than four "men." In families of four "men" and over the size of the family did not seem to exert the same effect upon the cost.

The Relative Proportion of Protein, Fat, and Carbohydrate in the Dietaries Studied. In expressing the proportion of the various food constituents it was deemed advisable to reduce them all to the common factor of "available calories." For this reason it is impossible to compare the proportions or gross figures with those obtained in similar investigations in which the proportion and amounts represent grams and not calories.

Table VI.—Proportions of Food Constituents

Family.	Total calories per man per day.	Percentage protein calories.	Percentage fat calories.	Percentage carbohydrate calories.
I. a.	2877	11.6	18.5	69.8
I. b.	2589	13.7	20.8	65.4
I. c.	2605	7.7	19.3	72.9
J. d.	3279	12.4	32.0	55.5
J. e.	2118	14.8	25.8	59.3
J. f.	2521	13.1	24.9	61.9
P. g.	2975	12.4	25.6	61.9
P. h.	2997	14.1	28.8	57.1
P. j.	3399	15.0	37.3	47.6
N. k.	2774	12.5	37.0	50.4
N. l.	2370	11.1	31.2	57.6
N. m.	3697	9.6	55.4	34.9
Average	2851	12.3	30.8	56.8

The most striking feature in the preceding table is the almost constant relation between the proportions of the various constituents in each family studied. In every instance the smallest proportion of calories is derived from protein, the next highest from fat, and in every instance but one the largest proportion is derived from carbohydrate. This one exception (Family N. m.) showed a greater proportion of fats than carbohydrates, due to the large amount of lard used, a fact which has been previously mentioned.

A comparison of the average proportions of the various constituents with the average of several investigations, cited by Atwater, among families of the same station in life as those under consideration shows that the two correspond to a remarkable degree. The percentage of protein calories was 12.3 in one series and 13.5 in the other, of fats 30.8 in one and 31.1 in the other, and carbohydrates 56.8 in one and 55.4 in the other.

It would therefore seem that no matter what variations might exist in the diets of individual families both in quantity and character of the food, similar groups of families show a remarkably constant proportion of the calories derived from the various constituents. The variation in the total number of calories obtained is very much greater than in the proportions of protein, fat, and carbohydrate.

TABLE VII.—FOOD CONSTITUENTS ACCORDING TO RACE

Race.	Total calories.	Protein calories per man per day.	Proportion of protein calories. Per cent.	Proportion of fat calories. Per cent.	Proportion of carbohydrate calories Per cent.	Cost of food per man per day.
Italian . .	2690	297.2	11.0	19.5	69.4	$0.1910
Jewish . .	2639	350.6	13.3	27.6	59.0	.2409
Polish . .	3123	432.8	13.8	30.6	55.5	.3469
Negro . .	2947	322.7	10.9	41.3	47.7	.2215

A comparison of the average composition of the food for each race shows that one of the chief differences between the dietaries consists in the variation in the relative proportion of fat and carbohydrate, the proportion of protein calories showing only a slight variation. It may be worth noting, however, that there was a constant relation between the number of protein calories and the cost of food per man per day.

In the Italian families the proportion of fats consumed was the lowest and the carbohydrates the highest of the races studied. The negroes gave the highest proportion of fats and the lowest carbohydrate, the other two races being almost midway between the Italians and negroes.

In other investigations of a similar character the greatest variation appears to have been between the proportions of protein and fat, the carbohydrates remaining fairly constant. The only explanation for the existing conditions may be found in the large quantity of fat in the form of lard consumed by one of the negro families (N. m.) In the figures cited by Atwater giving the proportions of the various food constituents found among the Italians, Russian Jews and negroes, the negroes showed the largest proportion of fats and the Russian Jews the highest percentage of protein, just as was found in the present study although to a greater extent. In both studies the negroes showed the lowest percentage of protein.

It seems rather remarkable that among civilized races, living under similar climatic conditions, in the food selected by the people in the poorer classes the proportion of the various constituents should so closely approximate one another. It would appear as though food requirements of the body had been gradually determined by experience and became standardized in course of time. No matter how the diet varies in its articles of food and method of preparation the relation of the various food elements remains remarkably constant. It might be urged that this may be due to the fact that the investigations were carried out in the same country. Three of the races studied were from foreign countries, living in a large city and to a great degree associating with their fellow countrymen, a condition which tends to maintain their natural customs and habits. The markets from which their food is selected is practically unlimited as far as variety is concerned. It can hardly be said that in the large cities of the United States the diet of any group of people could be influenced to any marked degree by the limitations of the market or influenced by the example of their new associates.

The proportion of protein found in the present investigation is distinctly lower than the standard or physiological proportion as given by Atwater and by Voit, 12.3 per cent. as compared to 14.8 per cent. and 16.1 per cent. Atwater does not give the proportion of fat and carbohydrates, but Voit gives a percentage for fat (16.8) which is approximately one-half the proportion encountered in the present study (31.1 per cent.), the carbohydrate percentage being accordingly much higher in Voit's standard figures.

It was thought that perhaps it might prove of interest to study the relation between the total protein calories per man per day and the cost of food per man per day (Table VIII). Charts were also prepared showing the relation between the cost of food per man per day and the percentage of protein, fat, and carbohydrate, the families being graded according to the amount or proportion of the various food elements and then divided into groups of three for greater convenience, with the average for each group.

TABLE VIII.—SHOWING RELATION BETWEEN PROTEIN CALORIES PER MAN PER DAY AND THE COST OF FOOD PER MAN PER DAY

Family.	Protein calories per man per day.	Cost of food per man per day.	Average protein calories.	Average cost.
P. j.	510.0	$0.4118		
P. h.	420.1	.3080	445.5	$0.3413
J. d.	406.4	.3041		
P. g.	368.3	.3210		
N. m.	356.3	.2496	359.9	.2665
I. b.	355.3	.2290		
N. k.	349.2	.2100		
I. a.	334.3	.1580	338.2	.1876
J. f.	331.3	.1950		
J. e.	314.3	.2238		
N. l.	262.8	.1850	259.7	.1986
I. c.	202.1	.1870		

There exists an apparent relationship between the number of protein calories per man per day and the cost of food per man per day, but this relationship is not so evident or constant as one might expect to find. The first group having the highest average number of calories shows the highest average cost, and the group with the second highest average calories the second highest cost. The group with the third highest average calories, however, shows an average cost lower than the group with the fourth highest average calories.

As will be seen later the protein is the most expensive of the food elements, and one would naturally expect to find it exerting a more constant or at least a more evident influence upon the cost of food. The influence of the protein upon the cost is seen when the families are studied according to the race, mention of which has been previously made (note under Table VII). When the families were grouped according to the race and the average for each race obtained the relationship between the protein calories and cost of food per man per day was found to be absolutely constant. The Poles showed the highest number of protein calories and the highest cost per man per day. The Russian Jews showed the second highest of each, the negroes third highest, and the Italians the lowest calories and cost.

It seems hardly justifiable to use the total protein calories as a factor in studying the relation between protein and cost, the total protein calories being influenced to such a marked degree by the total amount of food obtained. It would be much more correct to use the proportion of protein in such a comparison rather than the total amount of protein.

The relation between the proportion of protein and the cost was not found to be any more constant than the relation between the total protein calories and the cost, although this latter finding would certainly seem to have more significance than the former. One would naturally expect that the proportion of the most expensive food element would bear a fixed relationship to the cost of food.

The proportion of fat did bear a constant relation to the cost of food, the greater the proportion of fat the higher the cost, the increase in cost, however, not being proportionate to the increase in percentage of fat.

When the relation between the proportion of carbohydrate and cost was studied the relation was found to be not only a constant one but there was almost an absolute inverse ratio between the two, the cost of food decreasing proportionately with the increase in the percentage of carbohydrate. The relationship was so marked and so proportionate that it would appear as if the carbohydrate must be considered the most important element of the food in the maintaining or securing of an economical dietary.

In referring to protein, fat, and carbohydrate it must be remembered that in the present study the various elements have been considered separately regardless of the source of the element. For example, the protein referred to was considered as a whole, although it was derived from vegetables, legumes, dairy products, and meats. The source of the protein is, however, of considerable importance from an economic stand-point. This is the only possible explanation of the failure to note a more constant relation between the percentage of protein and the cost of food.

In the original tables each article of diet was considered separately, with the percentage of calories derived from proteins, fat, and carbohydrate given in full. The cost of the food was divided in the same proportions and assigned to protein, fat, and carbohydrate. For example, if twenty cents was spent for a certain article of diet containing 25 per cent. protein calories, 25 per cent. fat calories, and 50 per cent. carbohydrate calories the sum of five cents was credited to protein, five cents to fat, and ten cents to carbohydrate. In this way the actual cost of each food element was accurately obtained, it being then possible to determine the proportionate cost of each food element for each family.

TABLE IX.—SHOWING PROPORTIONATE COST OF PROTEIN, FAT CARBOHYDRATE

	Protein. Per cent.	Fat. Per cent.	Carbohydrate. Per cent.
Average percentage of calories	12.3	29.7	57.8
Average percentage of cost	20.2	37.4	42.3

	Protein.	Fat.	Carbohydrate.	Total.
Average calories per man per day	350.8	879.4	1620.9	2851
Average cost per man per day	$0.052	$0.094	$0.104	$0.2501

AVERAGE CALORIES FOR TEN CENTS

	Protein.	Fat.	Carbohydrate.
	674	935	1558
Ratio	1	1.4	2.3

AVERAGE COST OF 1000 CALORIES

	Protein.	Fat.	Carbohydrate.
	$0.148	$0.107	$0.064
Ratio	1	.70	.43

If the various food constituents are reduced to a common basis of the average cost of 1000 calories it will be seen that the protein was nearly two and a half times as expensive as the carbohydrates and almost half again as expensive as the fats, the fats being approximately one and two-thirds as expensive as the carbohydrates. It is very interesting to see the actual amount spent on the average for each man daily for protein, fat, and carbohydrate.

If the average number of calories had been derived from carbohydrate alone, at the relative cost for carbohydrate as given, the average daily cost of food per man would have been reduced from $0.2501 to $0.1825, or if derived from protein alone in the same manner it would have been increased to $0.4219. This must not be taken as a recommendation, but is merely stated to bring out more clearly the difference in cost of these two elements.

The protein is derived from various sources, and it was therefore thought it might prove of interest to see what the difference in cost would be according to the foodstuffs from which it was derived.

TABLE X.—NUMBER OF PROTEIN CALORIES OBTAINED FOR TEN CENTS (AVERAGE OF TWELVE FAMILIES)

		Ratio.
When derived from eggs, meats and fish	448	1.0
When derived from vegetables, legumes, fruits, dairy products, and mixed foods	1264	2.8

It was found that the total number of calories obtained from vegetables, legumes, fruits, dairy products, and mixed foods in the dietaries studied was 1.69 times that obtained from eggs, meat, and fish. It will be noted that the protein derived from eggs, meat, and fish is two and eight-tenth times as expensive as that obtained from the other sources.

STUDY OF THE DIETARIES IN DETAIL. The attempt was made to so arrange the dietaries that a comparison could be made between the different families. For this purpose a chart was made out for each family by which it was possible to determine which were the articles of food which were bought most cheaply and which were the expensive foods in the case of each family. When, however, an attempt was made to correlate these tables the number of the articles of food was so great that they did not lend themselves readily to comparative tables.

It was therefore deemed advisable to merely select from the dietary of each family the twelve or thirteen articles of diet from which the greatest number of calories was obtained, in other words, their main articles of diet. The number of calories obtained from each article was noted and for each family the approximate percentage of that article consumed was placed opposite.

The most striking feature of the charts thus prepared was the relatively large amount of bread consumed by every family. When the wheat bread, wheat rolls, and rye bread were combined it was seen that they constituted on an average 33 per cent. of the twelve main articles of diet. This average would have been much higher if one of the families (N. m.) had been omitted, five families giving a percentage of over 40.

One would naturally expect that the amount of meat and eggs consumed would affect to a great extent the cost of the food, as shown by the number of calories obtained for ten cents. While in a general way it can be said that the families with the larger proportions of meat were among those obtaining the fewer calories for ten cents, the relation was not an absolute one.

A study of the above dietaries would seem to show that within certain limits it was not so much the articles of food purchased which influenced the economy of the diet as much as it was the purchasing ability of the housewife. For example, when one studied the various articles of diet when purchased by different families one was struck with the distinct variation in the amount of nutriment obtained for the same amount of money. For example, wheat bread constituted a portion of the dietary of every family, the number of calories obtained for ten cents ranging between 1920 and 3901. This marked variation is probably due to the amount of stale bread used by the different families and also to the kind of bread used.

The variations in the amount of nutriment obtained for ten cents in the other articles of diet may probably be attributed to the differences in quality or grade, and the normal fluctuations in market price.

SUMMARY. From the study of the twelve families investigated one would seem justified in drawing the following conclusions:

The average dispensary family obtains about four-fifths of the nourishment it should receive.

Ignorance of the nutrient value of food and poor judgment in its purchase is the main cause of this state of affairs, although poverty is to a certain extent also responsible.

Education of the poorer classes in dietetics and food economy would undoubtedly, if made sufficiently wide-reaching, lead to a marked improvement in their nutrition and general well-being.

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PRE- AND POST-NATAL WORK

FROM THE PHIPPS INSTITUTE AND THE BABIES' HOSPITAL

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THE campaign having as its object the reduction of the infant mortality rate is undergoing the same evolution that has characterized other public health movements. In nearly every instance the initial step has been to treat individuals who have become ill. This unquestionably aids in saving the lives of many, no matter what the particular problem may be. But sooner or later it becomes apparent that the real solution lies in the prevention of disease. Those who have studied the causes of the high infant mortality rate have gradually come to see that marked progress is to be made only through the prevention of the illnesses common to young children rather than waiting until they become sick.

Except as it applies to the poor and ignorant, there is nothing new in pre-natal or pre-maternity work. Women in the well-to-do class practically always consult a physician early in the course of their pregnancy and are under medical supervision until they have passed safely the puerperal period. Women of the poorer class, on the other hand, rarely consult a doctor until the time of their confinement is near at hand; and in many instances, especially among the foreign born, the services of a midwife at the time of confinement are all the attention the woman receives. Only too often inadequate care is the result of poverty. This is shown by our experience. You will get some idea of the social background when you consider that in our series the size of the families ranged from two to eleven, and the income from nothing at all, or relief from a charitable agency, to from $3 to $20 per week.

The need of conserving infant life becomes apparent when it is appreciated that the very large proportion of deaths is due to preventable causes, and the solution of the problem lies in education. It is interesting to note that, as far back as 1876, W. L. Richardson[1] urged the necessity of instituting measures designed to reduce the morbidity and mortality rate among infants. His recommendations embraced practically every measure in force to-day; namely, frequent visits to the home, instruction in dietetics, day nurseries, playgrounds, maternity hospitals, etc. He ends his report with the following:

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[1] From Boston City Board of Health Report, 1876: Report on Infant Mortality, by W. L. Richardson, M.D.

> The study of public hygiene has already done much toward improving the sanitary conditions of our large cities and towns, but much remains to be done. The field for future work is large; unfortunately the laborers in it are few.
>
> Of all the questions engaging the anxious thought of sanitarians and deserving the study of those interested in the welfare of the human race, there is none which should call for more consideration than that which deals with the problem how to save the lives of those helpless to help themselves. It is surely for the highest interest of the state to see to it that no means are left untried which may prove, in the least degree, of service in saving the lives of those who may be the very ones to whom, at some critical moment, the state may have to turn for its own salvation and defence.

Unless one is committed to the Malthusian theory, it must be admitted that a growing population is one of the surest indications of national strength. A low birth-rate or an unduly high mortality rate among infants is viewed with indifference or apprehension, according to the need for an increase in the population. It never has been shown that a nation is threatened with ruin which increases in size as the result of its own birth-rate; on the other hand, a gradually-diminishing population means, sooner or later, a weakened and inefficient nation. The need of conserving infant life is most apparent in sparsely-settled communities where the development of the country is dependent on an adequate population. This is well illustrated in the Australian Federation. Here there awaits development a vast expanse of unoccupied territory and a relatively small population. For these reasons every effort is being made by the Australian Government to conserve infant life. Quite recently the government has made available a sum of money for every prospective mother unable to obtain proper medical care during and after confinement. In addition, nurses are being employed to supervise the babies during the first two years of life. It is furthermore proposed by the government to establish an adequate number of maternity hospitals for the care of women in the poorer classes.

Although this country is not at present threatened with a diminishing birth-rate, the need of pre-natal and post-natal work may be urged on the ground of economy. It is cheaper to supervise infants and keep them healthy than it is to maintain hospitals for their care if they become ill. Looking at the problem in a broader way, it is one of the most effective means whereby sanitation and the laws of hygiene can be taught. The strongest appeal that can be made for cleanliness in and about the house is the effect this will have upon the child.

It is not necessary to recall in detail the various accidents which may occur during pregnancy and which can be averted if the prospective mother is receiving competent medical attention. And, while the need of such supervision is obvious, it is but a part of the greater problem having for its object the conservation of infant life.

Pre-natal work has four objects in view: (1) the protection of the mother against the complications of pregnancy; (2) the improvement of the health of the mother that she may bear a healthy child; (3) arrangements for adequate confinement; and, most important, (4) the education of the mother as to the proper care of her baby after its birth.

Success in this phase of preventive medicine, as in every other branch of public health work, is measured by the thoroughness with which it is done. The work, to be effective, must be intensive; failure is sure to result if the attempt is made to handle large numbers in a superficial manner.

The equipment necessary for the proper conduct of the work should consist: (1) of an obstetrician; (2) a nurse who has had training in obstetrics, social service, and municipal health work; (3) a pædiatrist for the post-natal work; and (4) the services of an internist. The brunt of the work falls to the lot of the nurse, and care must be taken to see that she is not required to handle too large a number of cases. On her shoulders lie the responsibility of teaching the mother how to care for herself during pregnancy, and the more difficult problem of instilling into the prospective mother a knowledge of the laws of hygiene. The need of the services of an internist will vary. In the group which we report a considerable proportion (33.7 per cent.) of the women had either latent or active tuberculosis. It is obvious that team work between the obstetrician and internist is essential in such cases, as it requires more careful supervision to maintain health, and, in addition, the question may arise at any time as to whether it is advisable to terminate the pregnancy.

It has been estimated that 75 per cent. of the maternal mortality and morbidity occurring as a result of childbirth is the result of preventable causes. In 1850, and even ten or fifteen years later, the mortality in many of the large maternity hospitals ranged between 10 and 15 per cent. from puerperal sepsis alone, which does not include the many deaths due directly to dystocia. Fortunately, since that period many advances have been made and the mortality and morbidity have been materially diminished. During the last ten years the maternal mortality in the Maternity Hospital in this city was 0.694 per cent. from all causes.

Undoubtedly great advances have been made during the last twenty-five years in the science of obstetrics, and as a result the mortality has gradually lessened. This is highly satisfactory; nevertheless, statistics regarding this point are very misleading. The difference in the results obtained in well-conducted maternity hospitals and those secured from private practice in general are very striking, and, whereas the results from large hospitals are at least moderately satisfactory, those secured from general practice are far from what they should be. As most statistics are derived from institutions, where the better results are obtained, we are naturally more or less misled regarding the mortality from obstetric cases as a whole. Probably 85 per cent. of our women are delivered in their homes. The poor results often obtained in private practice are due to many causes, not the least of which is poverty. The proper conduction of a maternity case requires not only skill but time, and the fact that obstetric cases in general pay badly is a definite factor. Numerous visits by the obstetrician, the instruction in the hygiene of pregnancy and the hygiene of the puerperium and lactation, tests, measurements, etc., apart from the actual work of delivery, are time-consuming procedures and can hardly be expected for the small indemniture generally offered. Many other causes enter into this problem. However, the fact remains that obstetrics as generally practised outside of the maternity hospitals and that relatively small class of patients who can obtain skilful attendance is far from ideal. As a result the mortality and morbidity in the general run of cases are unusually high. This is especially so among the poor and ignorant.

Until at least very recent times even the best-conducted maternity hospitals in many instances did not do pre-maternity work. Often a patient with a bony pelvis so contracted as to preclude the possibility of a normal birth presents herself only at the onset of labor or, at best, such a short time before as to be of little value so far as the prophylaxis of dystocia is concerned. This is only one of many examples; malpositions, placenta prævia, eclampsia, and many other conditions, the early treatment of which is of the utmost importance, are often allowed to advance, to the jeopardy of the woman and her expected child. Untreated tuberculosis, syphilis, and other diseases are also definite factors, increasing both the maternal and infant mortality and morbidity. Although these complications are not preventable, many are, and adequate treatment is of the utmost importance. These are well-known facts, and detailed description would be unnecessarily time-consuming. In dealing with the class of cases treated at the Phipps Institute, the midwife enters largely into the problem. In this city efforts are now being made to improve these conditions, but this problem is such a large one and the questions so many-sided that advancement can only be made slowly. Cabot,[2] in an interesting article in a lay magazine, has recently emphasized the fact that the richest and poorest classes are the recipients of the best medical treatment.

The point which we wish to especially urge is that, while the well-to-do gravidara doubtless usually obtains adequate care, this is not so among the poor and ignorant, and even when the latter are confined in the best maternity hospitals their pre- and post-natal care is often far from satisfactory.

The need of better care is emphasized by Zinke.[3] He states that well-kept statistics, before this world-war show that within the German Empire annually 8000 women die during labor and confinement. In this country, where statistics of deaths and diseases are poorly reported, it is conservatively estimated (by DeLee, of Chicago) that 20,000 women die every year of puerperal causes. In only one-fourth of these cases is death due to eclampsia, apoplexy, rupture of the uterus, hemorrhage, heart-disease, or injury; in the other three-fourths the cause of death results from preventable puerperal complications. "Think what these figures mean. Accordingly, Germany has lost from puerperal causes during the last fifty years 400,000 women in the act of birth; in the United States of America, for the same period of time, 1,000,000 women have been the toll demanded by death in the confinement chamber alone. It may be that the figures are only approximately correct, inasmuch as our population has increased 40,000,000 during forty-five years. . . .

"One thing we can not get away from is this: up to the present, in the world's history, more women have died from preventable cause in the confinement chamber than there were ever men killed in all the battles of the past and present. But this is not all: the morbidity of pregnancy, labor, and confinement is from three to four times higher than the mortality. These are appalling figures. They are undeniably correct."

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[2] CABOT, R. C.: *American Magazine*, April, 1916.

[3] ZINKE, E. GUSTAV: *Bulletin of the Lying-in Hospital of the City of New York*, 1916, x, 303, 130–143.

It is with the hope of aiding the latter class of cases that the pre-natal clinic at the Phipps Intitute in Philadelphia has been instituted. The work at the Phipps Institute has been conducted along the following lines:

How Cases Are Obtained.—Our cases are referred to us for pre-natal care by the Phipps Institute, Babies' Dispensary, and the Washington Avenue Dispensary. A few come to us from the Society for Organizing Charity and the Young Women's Union. A knowledge of the work is gradually spreading, and it is now not uncommon for women to apply on their own initiative, even early in the gestation. About one-third are tuberculous; the time of pregnancy averages about the fifth month.

Pre-natal Care.—At her first visit the nurse does the housing and takes the social history, thus getting the background of the case. She then goes over the pre-natal instructions, advising patients as to the proper food and clothing, the necessity for exercise, general hygiene, etc. A specimen of urine is obtained and the blood-pressure taken. During the first few months of pregnancy the aim is to visit every two weeks; the eighth month, every ten days; and the last month, every week. The blood-pressure is taken every month and a specimen of urine secured at each visit; if any abnormality is present it is reported to the physician in charge and the patient told to come in for treatment. The proper kinds of baby clothes are advised, and patterns are furnished if the patient is able to use them. As many of our cases are receiving help from some charitable organization, and none of them have adequate incomes, this is not often done. We are fortunate enough to have layettes furnished for some of our more needy mothers, particularly for the Jewish ones.

Confinement.—In some instances they can afford a private doctor or have a family physician who will attend them, but if they have no one and prefer remaining at home they are given a note to one of the maternity dispensaries. Those who previously have had midwives are advised to either engage a physician or to arrange for confinement in a maternity hospital. Those patients who prefer a woman physician are referred to the Women's Medical College, Maternity Department. When the patient remains at home, instructions are given as to the supplies needed. If a hospital or maternity is advised by the physician, or the patient suggests such a course, she is given a note to one of them, and we see that a bed is reserved and arrangements made for her confinement. If there are children, we see that they are suitably placed, referring them to the Children's Bureau.

Post-natal.—After confinement no visits are made, so long as the visiting nurse is in attendance, which is usually for eight or ten days. After she leaves, a call is made and instructions given as to the bathing, feeding, and general care of the baby. The patient is urged to come to the Gynæcological Clinic as soon as possible for post-natal examination, and, if tuberculosis, for a chest examination as well. As soon as the baby is three or four weeks old the mother is asked to bring it to the Prophylactic Dispensary of the Babies' Hospital, where it is weighed, the temperature taken, and advice for keeping it in health given by the physician, who requests that it be brought every two or three weeks for observation. If it should be ill, it is referred to the Dispensary for Sick Babies of the Babies' Hospital. This closes it as a pre-natal case, and it is carried as a post-natal one, a visit being made each month to see that the instructions are being followed. If the child is not brought to the dispensary after three months, a visit being made every month and the necessity for keeping it well instead of waiting for it to become ill before taking it to the physician being emphasized, the case is completed.

Our total number of cases to March 1 was 175. Of these, 61, or 33.7 per cent., were tuberculous. There were but five maternal deaths in the entire series. One patient, non-tuberculous, died of malignant endocarditis; another, also non-tuberculous, died from œdema of the lungs and dilatation of the right heart, following a Cæsarean section. Three advanced tuberculous patients were treated in the Phipps Institute until the time of delivery, when they were removed to a maternity hospital. They lived some weeks after confinement, as did their babies. The time in which our cases come to us varies from the second to the eighth month, the average being the fifth month. They have been cared for as follows: not yet delivered, 23; closed because of removal from district or because they were uncooperative, 26; not pre-natal, 3; unattended, 2; in general hospital, 22;

in maternity hospital, 16; by dispensary doctors, 56; by private doctors, 15; by doctor and midwife, 1; by midwives, 11. Total, 175.

Of five miscarriages, two of the women were tuberculous; of four still-births, one of the women was tuberculous; and of eleven infant deaths, eight were children of tuberculous mothers.

The number of women who manifest evidences of active pulmonary or laryngeal tuberculosis, either during pregnancy or during the puerperal period, is sufficiently large to command attention. In some instances it is known that such a condition exists, but in a far greater number serious damage has resulted before the attending physician realizes the danger. The prevailing opinion is that the effect of pregnancy on a tuberculous lesion is most serious, and in a measure this is true. Most of the statistics dealing with this question, however, have been furnished by obstetricians, who are often consulted after the pulmonary damage has become irreparable. Many unfavorable terminations could have been avoided had the attending physician taken an adequate medical history. Thus, if the woman gives a history of having had a member of her immediate family die of tuberculosis, or if she herself has ever had an attack of pleurisy, an hæmoptysis, or a persistent cough, attention should at once be directed to the condition of her lungs. The experience at the Phipps Institute has shown very clearly that forewarned is forearmed, and that coöperation between the medical men and the obstetrician will carry many of these women safely through their pregnancy.

Fifty cases of pregnancy in tuberculous women have been thoroughly followed in the Pre-natal Clinic of the Phipps Institute during the last two years. These cases recently have been reported in detail by one of the authors.[4] In this series there was a morbidity of 22 per cent., in contradistinction to the 60 or 80 per cent. morbidity usually observed. There was an infant mortality of about 11 per cent. in the place of the 50 to 60 per cent. mortality generally noted. Many authorities view the incident of pregnancy in a tuberculous woman as an indication for emptying the uterus, regardless of the pulmonary condition and the advancement of the pregnancy. This tendency is especially present among the Germans. We feel that such a dictum is far too sweeping, and believe that this stand is confirmed by our results. It is not to be understood that we do not believe in therapeutic abortion in certain cases. This has been practised in five of the fifty cases above referred to. Intervention, to be effective, should be employed prior to the fifth month, and should be done early; that is, immediately upon the onset of any acute symptoms. Such a plan exposes the patient to the obvious risk that she may do well for the first half of pregnancy and suffer an exacerbation during the latter months.

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[4] NORRIS, CHARLES C.: "Pregnancy in the Tuberculous," *Amer. Jour. Obstetrics*, New York, April, 1916.

It is impossible to escape the well-established fact that every tuberculous woman who becomes pregnant is exposed to a distinctly added risk thereby. Doubtless a better plan in the majority of cases would be for the woman to avoid conception, and such advice on the part of the physician is undoubtedly the safest to give. In exceptional cases, where the disease is limited and non-active and has been in abeyance for a period not less than two years, and when the patient is willing and able to obtain adequate treatment, and a child is especially desirable, it is probably justifiable to countenance conception. Under all circumstances the patient should be under the care of a skilled internist and should receive regular and frequent examinations.

All our tuberculous cases have been kept under close observation and the necessity for treatment emphasized to them. In this connection it should be remembered that tuberculosis is only in the rarest instance congenital, the infection in these infants being post-natal in practically all cases. For this reason, and for the maintenance of their own health, these women should not nurse their infants, and the children should be especially guarded against post-natal infection. It would be highly desirable to have a Wassermann test made on each woman when she first comes under observation. Up to the present time it has been impossible to have this done, but in the near future we hope to include this in our routine work.

While the report on the pre-natal work is based on a study of 175 cases, the post-natal care includes results of only 100 babies, as the Prophylactic Dispensary was started some time after the pre-natal work at the Phipps Institute had been in operation.

The report of the post-natal work in the prophylactic care of babies is based on a study of one hundred cases which have been under our care in the Prophylactic Dispensary of the Babies' Hospital and Phipps Institute. The mothers of fifty-two of these patients received pre-natal care and were referred from the Phipps Institute; the remaining forty-eight were referred direct to the dispensary from various sources for observation in the Prophylactic Dispensary. In considering the statistics of the cases it seems preferable to consider the total number together, merely contrasting those from different sources for purpose of comparison as to the final results.

Of the one hundred cases upon which this report is based, thirty-six are closed cases—cases which paid only one or two visits to the dispensary and then for various reasons were no longer under observation, and sixty-four active cases in which we still have more or less constant supervision.

As most of our cases are of necessity from the surrounding territory, the situation of the dispensary would naturally have quite some influence on the nationality of the patients: thus 46 per cent. of the total number of cases are of Hebrew extraction, 29 per cent. of Latin extraction, and the remaining small number divided among the Slav, Negro, Teuton, and Celt. In 29 per cent. both parents were born in Russia, in 19 per cent. in America, in 18 per cent. in Italy, and—a rather interesting fact—in twenty-two instances the fathers were native-born Americans, but the mothers from foreign countries, principally Russia and Italy.

In considering the family history only one fact could with any positiveness be ascertained; namely, the presence or absence of tuberculosis. As regards the other diseases, notably syphilis and alcoholism, very little of a definite nature could be extracted, although in three instances there were quite visible evidences of alcoholism in the father, and in one case a positive Wassermann reaction was obtained from the mother. Out of the fifty-two cases referred from the Phipps Institute, there was a history of tuberculosis in one or more members of the family in twenty-four cases, nearly 50 per cent., the mother suffering in all except two instances, or in twenty-two out of the fifty-two cases. Of the forty-eight cases referred from outside sources, eight showed a family history of tuberculosis, the mother suffering with others in four cases.

As to the closed cases, of which there are thirty-six out of the total number of one hundred, they were considered closed either because they had not been to the dispensary for a period of one year, or else, because of some good reason, they had ceased to be visited by the nurse. Of these, twenty-one, or about 58 per cent., paid only one visit and were never seen again, and only twelve of the thirty-six had been seen at all by a doctor; most of them went to the dispensary before it was in full running order. They ceased their visits for various reasons: most of them said it was too far to come to the dispensary, several moved out of town, others were indifferent to the advantages to their children by such care, and still others came for more pecuniary advantages, and ceased their visits when it was found that free milk was not forthcoming on their first visit.

A study of the health of the cases still under our care is rather hard to particularize in statistics, but, for purposes of comparison of the cases with tuberculous history and those without, the gain per baby was divided by the length of time under observation, and the following deducted: The cases of tuberculous families made an average gain of 16⅞ pounds for 22¾ months, or about three-quarters of a pound per month, and the non-tuberculous cases made an average gain of $10^1/_5$ pounds for 9⅔ months, or a little over a pound per month—a very satisfactory gain when all the circumstances are taken into consideration.

As to the care of the patients themselves: Most of our cases are told to come back in usually from two weeks to a month, depending a great deal on the particular need of the individual, and the nurse makes her visits to the house usually in about the same averages—at least once a month in all cases, and oftener if found desirable, even going several times a week in certain particular instances.

The feeding of the patients has been as simple as possible. The great predominating fault with the breast-fed babies is that they are nursed too often and too irregularly, and the cases least amenable to improvement are the ones which it is impossible to convince the mother that the child should be nursed at regular hours, and not when she thinks of it during the daytime and when the child thinks of it at night. Wherever possible, breast feeding has been persisted in as long as practicable, and only as a last resort has artificial food been advised in the very young infants, except in cases of mothers with tuberculosis, when they had been taken off the breast immediately. Very often we have been able, by increasing the food supply of the mother, to increase her own milk and prolong the nursing period, and have shown in many cases an appreciable gain in weight in the infant. When nursing was no longer possible artificial feeding was commenced, and then our problem became more complex, as it was not so much what the infant could have to eat as what they could get to eat.

In the modification of milk only the simplest dilutions were in most cases advised, even no attempt at top-milk formulas being attempted; in most cases it was hard enough to get the mothers to understand what half milk and whole water meant. Milk with water or barley water as a diluent and the addition of sugar was usually all that was given; at times the sugar even was omitted, as the parents were unaccustomed to such luxuries. The mother, in the presence of the nurse, was told what to give, and then the following day visited by the nurse and instructed in the method of its preparation. For some time milk, bottles, and nipples have been sold at cost to the patients. Lately we have been able to get started a small milk fund, whereby we have had delivered to the homes of the deserving a quart of good milk—for the mother in case it was advisable to try and increase her breast supply; for the baby if it was on artificial feeding. This has been a wonderful help, and in several instances has been the turning-point in the health of the baby.

In general our results have been quite satisfactory. Out of the entire list of one hundred cases during the past year we have had only one death—a case which was seen only once, never returned, and died some time during the past summer from some, to us, unknown cause. Also, except for several minor and temporary ailments which have arisen from time to time, we have had only three sick children—two during the past summer from severe enteritis, and one who just recently became ill—all three strangely in tuberculous families. Except for these instances, the infants have all done remarkably well when one considers the disadvantages under which they labor—ignorance, poverty, and filth. As a whole, the mothers have proved quite receptive and anxious to do their share in the promotion of their babies' health. This has been due in great measure to the kindness, wisdom, and tact of Miss Roche, our visiting nurse; for, while it is true that the parents wish to see a doctor and hear from his lips the direction of the baby, yet it is equally true in such work that without the services of a well-trained and capable nurse the directions would lose half of their value.

We have been greatly aided by the effective coöperation of the University Hospital, Woman's Hospital and Barton Dispensary, Maternity Hospital, Jewish Maternity, Jefferson Maternity, Southeastern Dispensary, and Polyclinic Hospital.

The work has been made possible by the very effective manner in which it was organized by Miss Stringer, head of the Social Service Department of the Phipps Institute.

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LATENT SYPHILITIC INFECTION OF THE LUNGS.

By H. R. M. Landis, M.D.,
and
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Philadelphia.

The only type of pulmonary syphilis about which there is a general agreement is that seen in newborn syphilitic children. In this form of the disease, gummata may occur, but, as a rule, they are rare. The typical lesion is that known as white pneumonia. The lung presents on section a dry, smooth surface, grayish or yellowish white in color, resembling closely the cut surface of the pancreas. The process may occur in scattered patches throughout both lungs or may involve the entire lobe. This type of pulmonary syphilis is, for the most part, of pathological interest only.

In acquired syphilis most writers describe two main types of the disease as it occurs in the lungs, namely, the formation of gummata or an extensive cellular infiltration which leads to fibroid changes. If the disease assumes the indurative type, and this is by far the most common form, it usually originates at the hilus of the lung and extends outward along the bronchi and bloodvessels. The process is usually unilateral, and at most involves only a portion of one lobe; if several lobes are implicated it is the portions which adjoin the root of the lung.

In addition to these types a focal form has been described in which the lesion consists of an area of consolidation and catarrh. It is usually situated around the root of the lung, but may occur at one apex.

Whether the disease manifests itself in the form of gummata as a diffuse fibrosis or as a focal lesion, most of the cases reported indicate that the base of the lung or the area about the hilus, rather than the apex, is the part most frequently attacked. This fact is usually cited as one of the strong differential points between syphilis and tuberculosis. The general opinion has been that the apices are rarely involved, but it would be rather surprising, in view of the wonderfully diverse forms in which the localization of syphilis manifests itself, if the upper portions of the lungs should always escape.

We believe that pulmonary syphilis of a latent type occurs far more frequently than is usually supposed. The form to which we wish to call attention is that in which the localization occurs in the apices of the lungs. This type of the disease may simulate early pulmonary tuberculosis so closely as to deceive us entirely. How closely the two diseases may resemble each other is illustrated by the following cases:

Case I (Phipps Institute, No. 9485).—Female, aged twenty-eight years, first came to the Phipps Institute June 10, 1911. Her first pregnancy had resulted in a miscarriage. She gave a history of having had repeated attacks of blood-spitting for five years. During the two years prior to her coming to the dispensary she had lost thirty pounds in weight, and for a year had had a cough, considerable greenish expectoration, and night sweats. She also complained of pain posteriorly over the base of the right lung. There was a slight elevation of temperature, 99° to 100° F.

Examination. There was some flattening beneath the right clavicle, diminished expansion, impairment of resonance on percussion, and bronchovesicular breathing.

She was sent to a sanatorium and remained away for several months, where she gained about sixteen pounds in weight, but the pulmonary symptoms remained unchanged. On her return to the Phipps Institute her sputum was repeatedly examined for tubercle bacilli as well as other organisms, but always with a negative result. Guinea-pigs inoculated with her sputum were killed after an interval of several months, and showed no evidence of tuberculosis. At the end of ten months her condition, aside from some gain in weight, was about the same as when first seen. A Wassermann test taken at this time was strongly positive. She was then given salvarsan, followed by mixed treatment, which was continued for months. Following the salvarsan the symptoms at once began to improve, and she has apparently made a complete recovery. Three subsequent Wassermann tests have been negative. During the past year she has given birth to a healthy child. At the present time (May 15, 1915) she weighs 188 pounds, and is entirely free from pulmonary symptoms.

Case II (Phipps Institute, No. 9617).—Male, aged thirty-three years, husband of the previous case. First visited the Phipps Institute July 6, 1911, stating that he had had a cough and greenish-colored expectoration for the past two years. He also complained of pain posteriorly over the base of the right lung. He had lost weight and had a slight elevation of temperature in the afternoon.

Examination. Patient was quite anemic. Expansion was diminished beneath the right clavicle, the percussion note was impaired, and the breathing bronchovesicular, with a harsh, prolonged expiratory sound.

He was also sent to a sanatorium, and remained away for six months. Although he gained forty pounds in weight the pulmonary symptoms persisted, and in addition his sputum was blood-streaked at times. On his return to the Phipps Institute his sputum was repeatedly examined for tubercle bacilli and other organisms and also inoculated into guinea-pigs, but with negative results. A Wassermann test taken about a year from his first visit was found to be strongly positive. The administration of salvarsan and later mixed treatment caused a disappearance of his pulmonary symptoms. At the present time (May 15, 1915) he is apparently in perfect health.

CASE III (Phipps Institute, No. 4050).—Male, aged twenty-nine years, was first seen in the dispensary of the Phipps Institute April 7, 1906. He came because of loss of weight, dyspnea on exertion, and morning cough and expectoration. On several occasions the sputum had been blood-streaked.

The family history was negative. He admitted having had gonorrhea eight years previously, but denied ever having had syphilis.

EXAMINATION. When first seen there were fine crackling rales at both apices, but otherwise the pulmonary signs were negative. The heart was normal. The sputum was negative.

This patient was seen at intervals during the next two years, and for a period of two months, in 1908, was treated in the wards of the Institute. During his stay in the hospital the temperature chart showed frequent elevations, ranging from 99° to 99.3° F. While in the hospital he was given three injections of tuberculin. Following the third injection of 10 mg. there was a slight elevation of temperature. While his symptoms and general condition remained unchanged the rales at the apices had disappeared. The sputum continued to be negative for tubercle bacilli. On leaving the hospital he returned to the dispensary on several occasions, and then ceased to come. After an interval of four years he again reported March 30, 1915. His weight was the same as when last seen. He still had slight fever, and the morning cough and expectoration persisted. In addition he complained of nocturnal pain in his arms and hands and attacks of substernal pain and dyspnea. He had been married about a year when first seen in 1906. In the intervening nine years his wife had given birth to six healthy children.

The physical examination at this time showed no abnormality in the lungs. There was, however, a diastolic murmur at the aortic area. Believing this to be syphilitic in character a Wassermann test was made, which proved to be strongly positive. This case is of special interest because of the long duration of the pulmonary symptoms and the latent character of the trouble.

CASE IV (Phipps Institute, No. 13391).—Female, aged thirty-four years, first visited the Phipps Institute August 20, 1914. Her family history was negative. She had been married eleven years and had had three miscarriages. No living children. There was no history of an initial lesion or of secondaries. She came to the dispensary because of a cough, greenish-colored expectoration, night sweats and some loss in weight. In addition she complained of precordial pain, which had been present intermittently for six years. For four years she had suffered from attacks of burning and tingling in the legs.

EXAMINATION. Some flattening beneath the right clavicle, impairment of the percussion note, and bronchovesicular breathing. Heart was negative. The reflexes were exaggerated.

During the first six months she was under observation the night sweats, morning cough, and expectoration persisted, and the sputum was blood-tinged on one occasion. There was also a slight rise in temperature. The sputum was negative for tubercle bacilli. In February, 1915, she first complained of nocturnal headache. This gradually became worse, and finally was so severe as to interfere with her sleep. The Wassermann test was strongly positive. Under mixed treatment the headache was relieved. Later, following the administration of salvarsan, the cough ceased and the amount of expectoration was greatly reduced.

CASE V (seen in consultation).—This patient was a young male who, when first seen, had been gradually losing weight for three months; during this time he had a slight, hacking, and unproductive cough. He was anemic, had a slight afternoon rise in temperature, and in addition had marked malaise.

EXAMINATION. At the right apex there was slight diminution in expansion, some impairment of the percussion note, and a feeble respiratory murmur.

The case seemed to be clearly one of incipient pulmonary tuberculosis, and he was accordingly advised to spend the winter at a health resort. He returned six months later with his general health improved in every way, but in the course of a few months his symptoms began to return. At this time his physician noted that the sternal end of the right clavicle was enlarged and tender. The Wassermann test was positive. After two doses of salvarsan he had no further trouble, and has remained well during the past three or four years.

It is to be noted that the symptoms in all of these cases were characteristic of pulmonary tuberculosis, namely, morning cough and expectoration, blood-streaked sputum, loss of weight, and a slight elevation of the temperature. In two there was pain resembling that occurring in pleurisy at the base of the right lung. Furthermore, they all had physical signs indicative of incipient tuberculosis.

Some years ago E. G. Janeway[1] pointed out that when the viscera became involved during the tertiary stage of syphilis there is apt to be a moderate amount of fever, a loss of weight, and night sweats. Furthermore, a careful physical examination will often reveal some other noticeable evidence of syphilis, such as enlargement and tenderness of the ribs, clavicles or tibiæ, or an enlarged or indurated testicle. Warthin[2] has emphasized the fact that next to the aorta and heart the testes are the most frequent sites of a syphilitic infection. In a pathological study of 36 cases of syphilis occurring in males, the majority of which were latent and unrecognized during life, an orchitis fibrosa was present in 31. In the case of women a history of miscarriages is extremely significant.

If the lungs are involved there is, in addition to the symptoms mentioned above, cough, which may be dry and unproductive or accompanied by a moderate amount of greenish or yellowish expectoration. Blood-streaked sputum may also occur. Pain at the base of the right lung is not infrequent and may be misinterpreted; it is usually due to a syphilitic perihepatitis and not to pleural inflammation.

The presence of latent syphilis of the lung is to be suspected if in addition to pulmonary symptoms there are present elsewhere in the body lesions which are in all probability luetic in nature, such as a periostitis, orchitis, iritis, or suspicious throat lesions. The recognition of these cases should be relatively easy.

The type of the disease which offers the most difficulty, and which for the most part, escapes detection, is that in which the symptoms are entirely pulmonary and in which there are no associated syphilitic lesions. The 5 cases we have reported were of this type. In 2 (Case I and II) we were unable at any time to detect manifestations of the disease in other parts of the body. In the other three the clinical picture in the beginning was that of tuberculosis, but the subsequent appearance of an aortitis (Case III), of nocturnal headaches (Case IV), of an osteoperiostitis (Case V), and the presence of a positive Wassermann reaction made it apparent that we had to deal with syphilis rather than with tuberculosis. The correctness of this assumption received additional confirmation in view of the fact that the symptoms were relieved as the result of the administration of antisyphilitic treatment.

The diagnosis must be made by exclusion. Thus if the symptoms and physical signs are those characteristic of tuberculosis and the sputum does not contain tubercle bacilli, or the progress of the case differs from that usually encountered in tuberculosis, the possibility of some other exciting cause should be thought of. Not only should the sputum be examined for organisms other than the tubercle bacillus, but in addition a Wassermann test should be made in every doubtful case.

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[1] Trans. Assoc. Amer. Phys., 1898.

[2] Ibid., 1914.

The therapeutic results in these cases have been specially gratifying. In 4 the use of salvarsan was followed by an almost immediate relief of the symptoms. The remaining case has not been seen since the administration of that drug.

It is now recognized that salvarsan is much more effective in some forms of syphilis than it is in others. Skin lesions, for instance, clear up rapidly under the use of salvarsan, and the same seems to be true of pulmonary lesions.

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Postmortem Examinations after Artificial Pneumothorax.

PAUL A. LEWIS, M.D., AND CHARLES M. MONTGOMERY, M.D.

(From the Henry Phipps Institute of the University of Pennsylvania.)

Three cases of artificial pneumothorax induced in the course of pulmonary tuberculosis have developed pyopneumothorax which has resulted in death.

Abstracts of the records of the postmortem examinations are as follows:

CASE I.—M. S. Right pleural cavity contains 1300 c.c. of purulent fluid. The right lung is compressed to an irregular, rather flabby, flat, sausage-like mass which lies for the most part on the spinal column. It presents a convexity towards the right which projects at its farthest point to opposite the right nipple. There is a thumb-like projection of collapsed lung to an adhesion attached almost directly under the right nipple. Four other cord-like adhesions about 4 mm. thick and varying between 7 and 12 mm. in length run from upper portion of lung to thoracic wall in superior portion of thorax, two anterior and two posterior and lateral. These adhesions seem to have served to suspend the collapsed lung in the thoracic cavity. Compression fair but not complete.

CASE II.—J. H. The left pleural cavity contains 2000 c.c. of thick yellow-gray pus. The left lung is almost completely collapsed against the spinal column and the fibrous tissue of the posterior mediastinum. At the apex the pleural cavity is partly filled with a dense fibrino-fibrous exudate surrounding the apex of the lung itself. In this exudate, when it is torn away, are found several large cavities containing a thick whitish-yellow pus. These cavities communicate with a single cavity in the lung tissue, about two inches in diameter, presenting no communication with the bronchi, but opening externally into the fibrous exudate before mentioned by a definitely outlined aperture about one inch in diameter. The pus cavities in the fibrous tissue about the apex of the lung extend through the parietal pleura along the posterior walls of the thorax, just below its very apex. The ribs in this region are irregularly corroded. Pus does not extend beyond the musculature at any point.

All of the left lung except that immediately surrounding the cavity just described is collapsed to a layer about ¾″ in thickness by 4″ x 8″ in surface dimensions. On section it is found to be covered on both sides by a rather dense fibrous layer approximately ⅛″ in thickness. The picture on section is that of a relatively normal collapsed lung. The fibrous tissue does not seem to be greatly increased in the lung. There are a few scattered small collections of pus, which as a rule are not surrounded by any well defined zone of inflammation.

Case III.—M. H. The left lung is collapsed into the upper one-fourth of the pleural cavity. It is surrounded by a moderately firm adhesion on its upper aspects. The consolidated tissue is infiltrated with pus contained in very irregular small cavities and bronchial dilatations. One of these cavities communicates by a narrow opening through a dense fibrous wall at the lower aspect of the lung with an abscess cavity in the region of the lower pleural space. This abscess cavity is surrounded by a thick firm mass of fibrous tissue which completely obliterates the pleural cavity in its lower two-thirds.

Microscopic Examination of the Three Cases. Microscopic examination shows in all preparations a great increase in interstitial fibrous tissue. The alveoli are for the most part recognizable and the epithelium is distinctly cubical. In places the alveoli are empty, in others they contain desquamated cells or pus cells in all conceivable combinations. In Case 3 the interstitial overproduction of fibrous tissue merges throughout the sections into massive white tissue formations. In Case 1, this massive fibrous tissue formation has not occurred to any extent. The interstitial tissue in many places contains large collections of lymphocytes and related cells. Throughout all the sections evidences of tuberculosis of very irregular distribution and very diverse stages are found. Some of the tubercles and tuberculous masses are evidently being replaced by fibrous tissue. This is especially true in the sections from Case 3. In other instances the tuberculous masses do not differ from those seen under ordinary circumstances. Small tuberculous cavities are recognizable in Case 1. These are associated with evidences of acute inflammation.

These examinations lead to the conclusion that the induced pneumothorax at present so popular is a procedure entailing very real dangers. The infection of the pleural cavity was most probably from the affected lung in each instance. Such lung tissue as remained on the compressed side was damaged beyond hope of repair in each case. *March* 12, 1914.

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Effect of Ligation of the Pulmonary Vein of the Rabbit.

G. L. Kite, M.D.

The branch of the pulmonary vein to the right middle lobe was selected for ligation. A tracheotomy was performed and a small rubber catheter passed into the trachea to the point of bifurcation. The catheter was connected with an ether bottle and the lungs aërated by an insufflation apparatus.

During the first five days after ligation of the branch of the pulmonary vein to the right middle lobe, the alveoli of this lobe become filled with an exudate consisting almost wholly of mononuclear macrophages of the endothelial type; at about the end of two weeks the exudate and normal tissue are very largely replaced by fibroblasts; and as early as a month or six weeks from the time of ligation the fibroblasts are replaced by tough connective tissue. Such a lobe is considerably reduced in size.

The intravenous injection of virulent bovine tubercle bacilli either one day before or one or two days after the ligation of the vein does not noticeably alter the types of cells appearing in the exudate, or prevent the replacement of exudate and lung tissue by fibroblasts.

The macrophages which appear in the exudate have been studied in hanging-drops of fresh rabbit blood serum, and unequal cell-division and ameboid movement observed. The pseudopods are very blunt and are of the hyaline type. *March* 12, 1914.

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THE DETERMINATION OF IODINE IN THE PRESENCE OF ORGANIC MATTER.

By ROBERT B. KRAUSS.

(From the Henry Phipps Institute of the University of Pennsylvania, Philadelphia.)

(Received for publication, June 19, 1915.)

The quantitative determination of iodine in organic tissues, especially the iodine content of tuberculous tissues,[1] has occupied our attention in this laboratory for some time. Various methods have been proposed for such determination, those of Baumann,[2] Bourcet,[3] Hunter,[4] and Kendall[5] having attracted the most attention.

The Baumann method has been modified repeatedly and while it no doubt gives good results in experienced hands, the modifications indicate the dissatisfaction that has been felt with it. This method is not delicate enough for our particular purpose.

That of Bourcet requires large amounts of material (100 grams) and involves a subsequent liberation of the small amounts of iodine present. The first requirement it is seldom possible to fulfill, while the second is always a rather unsatisfactory procedure.

The method of Hunter has a serious drawback in the formation of oxychlorine compounds as pointed out by Foerster and Jorre[6] as well as Kendall.

Kendall's method has, in the past, in this laboratory given results that were generally satisfactory, but we have occasionally had cases in important series that gave blanks when the presence of iodine was certain, and on the other hand found traces which it seemed reasonable to believe were not present in the sample.

[1] Lewis, P. A., and Krauss, R. B., *Jour. Biol. Chem.*, 1914, xviii, 313.

[2] Baumann, E., and Roos, E., *Ztschr. f. physiol. Chem.*, 1895–96, xxi, 489.

[3] Bourcet, P., *Compt. rend. Acad. d. sc.*, 1899, cxxviii, 1120.

[4] Hunter, A., *Jour. Biol. Chem.*, 1909–10, vii, 321.

[5] Kendall, E. C., *Jour. Am. Chem. Soc.*, 1912, xxxiv, 894.

[6] Foerster, F., and Jorre, F., *Jour. f. prakt. Chem.*, 1899, lix, 53.

To cover all contingencies it would become necessary to have a method filling the following requirements:

1. To be capable of detecting most minute traces of iodine.
2. To use a minimum of sample for the analysis.
3. To introduce no iodates or iodides.
4. To eliminate foreign active halogens as reagents.
5. To be rapid and of general application.

In the following pages I wish to present a method I have developed which seems to meet these requirements in greater measure than any of those which have been used previously.

The Palladium Iodide Colorimetric Method.

It is known that the precipitation of palladous iodide affords a method of separation of iodine from bromine and chlorine.

Palladous iodide is insoluble in water, alcohol, acetone, and ether; insoluble also in dilute hydrochloric and hydriodic acids. This method is based on the fact that palladous chloride when added in the cold to a dilute solution of iodide gives a deep brown color due to the formation of palladous iodide.

The value of iodine to which this color is due is approximated by comparison with a standard, and obtained absolutely by comparison in a Duboscq colorimeter. A change of color due to 0.01 mg. of iodine as iodide, is easily seen with the naked eye and the colorimeter gives a further range of 1 to 100.

The determinations are usually made in a dilution of 100 cc. This corresponds to 0.0001 mg. per 1 cc. It will therefore be seen that by working in small volumes such traces may be easily detected. The method of procedure follows.

Detailed Description of Method.

The amount of substance to be taken varies with the chemical properties of the compound, especially the iodine content. For thyroids running about 2 mg. per gram 0.5 gram of dry substance is sufficient. Larger amounts offer no disadvantage; the iodine is then determined in an aliquot portion.

The substance is mixed in a nickel crucible with about 8 grams of a mixture of 1 mol. each of pure anhydrous sodium carbonate, potassium carbonate, and potassium nitrate; and then covered with an additional 5 grams. The lid is placed on the crucible, leaving a small opening for the escape of waste gases.

The crucible is heated in a crucible muffle such as described by me in connection with the analysis of iodine trypan red dyes.[7] Such a one keeps the waste gases from the crucible but gives an even heat on the sides and the bottom. As soon as the contents of the crucible cease burning the heat may be increased until the edges of the mass just begin to melt, but not higher. By this time all carbon has disappeared and on removing the crucible and cooling, the contents are nearly always pure white. This requires about ten minutes. I have found that a moderately rapid burning is desirable, which is also the opinion of Hunter[8] and Oswald.[9] On cooling, water is added to the melt, the lid washed, and the crucible is placed on the hot plate. As soon as the contents have dissolved the liquid is carefully poured through a funnel into a 200 cc. Erlenmeyer flask (using larger flasks for larger melts), washing the crucible carefully with a fine-jet wash bottle. It is desirable here to keep down the volume of water as far as possible. In order to reduce any trace of iodate that may have been formed about 2 cc. of a 10 per cent solution of bisulphite are now added, and phosphoric acid (85 per cent) is carefully added to the inclined flask which is agitated between additions. A slight excess of acid should be used. A small corner of litmus paper is a convenient indicator. After standing for a few minutes, sufficient sodium carbonate is added from the tip of a spatula to make the solution alkaline.

An inclined funnel is placed in the neck of the flask to prevent splashing and the solution evaporated on a hot plate to the stage where it just remains liquid when cold.

On cooling, about 20 cc. of acetone are added from a wash bottle, washing the funnel and sides of the flask.

The flask is shaken until the salts form a semi-solid layer at the bottom. Absolute alcohol is added in 5 cc. portions with agitation and the extraction of the iodide aided by working the salts with a stirring rod, which is then used as an aid in decanting the acetone-alcohol mixture.

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[7] Krauss, R. B., *Jour. Am. Chem. Soc.*, 1914, xxxvi, 962.

[8] Hunter, *loc. cit.*

[9] Oswald, A., *Ztschr. f. physiol. Chem.*, 1899, xxvii, 31.

The use of acetone first seems to favor the complete extraction of the iodides.

By the time 40 cc. of solvents have been used the iodide is nearly always removed. Confirmation may be obtained by adding a drop or two of standard palladous chloride solution. If the solution remains colorless all the iodine has been extracted.

The solvent is decanted through a filter directly into a Nessler tube if a quantity of iodine below 1 mg. is involved; otherwise into a graduated flask, and diluted to definite volume with alcohol. In the latter case an aliquot portion is used for the estimation in the Nessler tube.

The following dilutions are best suited for accurate determinations.

Above 10 mg.	Dilute with water to 1 liter and determine iodide in an aliquot.
1 -10 mg.	Dilute to 500 cc. with water and determine iodide in an aliquot.
0.1 - 1 mg.	Filter directly into 100 cc. tubes.
0.001- 0.1 mg.	Evaporate if necessary and determine in 50 cc. tubes.
	In smaller volumes, 2 to 5 cc., it is possible to detect and estimate amounts of iodine as low as 0.0001 mg.

Dilute palladous chloride solution, 0.0005 gram per cc., acidulated slightly with hydrochloric acid, is added drop by drop, until the color no longer deepens. Of such a solution 2 cc. are sufficient to combine with about 1.5 mg. of iodine. Of the same solution 2 cc. diluted to 100 cc. give no perceptible color.

The standards are prepared as follows.

Standards.

A solution of pure potassium iodide containing 0.1 mg. per cc. is prepared by weighing out 1.31 grams of potassium iodide, making up to 1 liter, and diluting 100 cc. of this solution to 1 liter.

The requisite standard for any weight iodine, say 0.1 mg., is made up by measuring out 1 cc. of the standard iodine solution in a 1 cc. pipette calibrated to 0.01 cc. into a 100 cc. Nessler tube, diluting with 10 cc. each of alcohol and acetone and adding about 1 cc. of standard palladous chloride solution, then diluting with water to the mark. According to the weight of iodine present the color ranges from a light brown to a deep red-brown. The comparison is made after the tubes have stood at least five minutes.

Standards should be made up with approximately the same ratios of acetone, alcohol, and water as the unknown.

The colors develop best in more concentrated solutions; therefore the palladous chloride is added before diluting.

The unknown is compared with a series of standards; the nearest match is determined by inspection. A difference of 0.01 mg. of iodine is easily seen with the naked eye and is sufficient for ordinary work.

For better results the unknown and the nearest standard are compared in a Duboscq colorimeter which has a further range of 1 to 100.

I have devised an electrolytic procedure by means of which the palladous iodide precipitated in the colorimetric method is electrolyzed; the palladium and iodine are deposited on separate electrodes and weighed.

This forms a good check on a series of colorimetric determinations involving small weights of iodine per determination and gives good results on single determinations involving larger weights of iodine. It also gives accurate results when used for direct estimations.

The details of the electrolytic determination of iodine in organic matter will be reported shortly.

The following tables of analyses will give some information as to the results obtained by this method.

In Table I are given results obtained by fusing 0.5 gram of pure casein with the stated weight of iodine as potassium iodide, obtained by pipetting from a standard iodide solution; and finally determining the iodine by this method.

In Table II are given results of analyses on a commercial thyroid preparation marked 0.2 per cent iodine, giving a comparison between Kendall's method and the palladous iodide method. 0.5 gram samples were used and the results are expressed in mg. per gram.

Table III contains results of analyses on three samples of commercial thyroid preparations. Results are expressed in mg. of iodine per gram of sample.

TABLE I.

No.	Casein.	Iodine present.	Iodine found.	Dilution.
	gm.	mg.	mg.	cc.
1	0.5	——	——	10
2	0.5	——	——	10
3	0.5	0.001	0.001	10
4	0.5	0.005	0.005	10
5	0.5	0.010	0.009	50
6	0.5	0.050	0.051	50
7	0.5	0.100	0.100	50
8	0.5	0.500	0.499	100
9	0.5	1.000	0.999	100
10	0.5	1.500	1.498	100
11	0.5	2.000	1.998	100

TABLE II.

Thyroid, 0.2 per cent iodine.

Kendall.	Colorimetric.
mg.	mg.
2.07	2.028
1.91	2.020
1.77	2.000
2.36	2.040
1.92	2.018
2.01	2.020
2.14	2.015
2.24	2.031
2.12	2.040
1.98	2.008

Table IV contains characteristic analyses of organic iodine compounds. The colorimetric determinations were made in 100 cc. dilution. Of the iodide extract made up to 100 cc. in graduated flasks, 1 cc. was used for the determinations.

The writer is aware of the fact that the reaction between iodates and iodides as usually applied to the estimation of iodine may be combined with the colorimetric method explained above, thereby increasing the delicateness of both. Some of the advantages of the present colorimetric method are, however, lost thereby. Work on both this modification and the electrolytic estimation of iodine present in animal tissue is under way in this laboratory and will be reported shortly.

TABLE III.

No.	Weight taken.	Iodine found.
A	*gm.*	*mg.*
1	0.5	2.022
2	0.5	2.042
3	0.5	2.040
4	0.5	2.036
B		
1	0.5	1.888
2	0.5	1.896
3	0.5	1.896
C		
1	0.5	1.904
2	0.5	1.896
3	0.5	1.892
4	0.5	1.916
5	0.5	1.884

TABLE IV.

Substance.	Weight taken.	Iodine found.		Iodine calculated.
	gm.	*mg.*	*per cent*	*per cent*
Di-iodo-diphenyl......	0.1020	63.81	62.55	62.56
	0.1008	63.06		
Iodo-acetanilid........	0.1016	49.40	48.62	48.65
	0.2024	98.46	48.64	
Iodo-benzoic acid.....	0.2002	102.52	51.20	51.21
	0.2041	104.51	51.20	
	0.2011	102.98	51.20	

SUMMARY.

1. In a solution of iodides, the iodine present may be estimated directly by the palladous iodide colorimetric method.

2. The iodine present in animal tissues can be estimated after fusion by the same method.

3. No iodides, iodates, or halogens, usually the source of errors, are added in this method.

I am indebted to Dr. Paul A. Lewis for valuable suggestions and criticisms.

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THE ELECTROLYTIC DETERMINATION OF IODINE PRESENT IN ORGANIC MATTER.

BY ROBERT B. KRAUSS.

(From the Henry Phipps Institute of the University of Pennsylvania, Philadelphia.)

(Received for publication, January 29, 1916.)

In a previous paper[1] a method for the determination of the iodine present in tissues or other organic matter was described in detail. This method consists essentially of a fusion, reduction of any iodate formed, careful extraction of the iodides, precipitation with palladium chloride, and the estimation of the palladous iodide formed by colorimetric comparison with a standard solution of that substance.

This method has as a matter of practice been entirely satisfactory. It is far more sensitive than any method previously used and it is free from the objectionable features of several of the earlier procedures. As our immediate interest in the matter rested on the determination of iodine in tuberculous tissues,[2] obviously very complex, and in amounts frequently so small as to be barely perceptible by even this most sensitive method, it has seemed desirable to check the procedure in every possible way. I have therefore developed an electrolytic method of analysis to cover the same ground.

As the method already published involved the colorimetric determination of the palladous iodide formed in the reactions, so this further development has resolved itself into the problem of estimating the palladous iodide electrolytically. The amount of palladium and the amount of iodine are both determined, checking each other by calculation. This method is far less sensitive than the colorimetric determination. It can be used advantageously as a direct method of analysis if the amount of iodine involved is relatively large, ± 0.0005 gm. After a series of determinations by the colorimetric method each involving amounts of iodine much smaller than this, it is advantageous to collect all the material and repeat the analysis electrolytically, thus making certain that there has been no gross error.

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[1] Krauss, R. B., *J. Biol. Chem.*, 1915, xxii, 151.

[2] Lewis, P. A., and Krauss, R. B., *J. Biol. Chem.*, 1915, xxii, 159.

The following observations by previous workers bear on the problems involved in the electrolytic method.

Whitfield[3] estimated iodine electrolytically proceeding from the silver salt, weighing the metal after electrolysis. Vortmann[4] has developed an electrolytic scheme for the estimation of pure potassium iodide. Specketer[5] estimates iodine by electrolytic methods, using graded potentials.

None of these methods are suitable for routine determinations. The quantities of chlorides and bromides present interfere with the first two; the low and absolutely constant voltage as well as the necessity for absolute exclusion of air and definite acid concentration makes the last unsuitable.

That palladium can be deposited from a solution of palladammonium chloride was found by Smith[6] and Keller.[7]

It is well known that palladous iodide affords a separation of iodides from chlorides and bromides, and that it is insoluble in water, alcohol, ether, and dilute hydrochloric acid.

Method.

The substance to be analyzed is fused and treated exactly as in the colorimetric method until the alcohol-acetone solution of iodide is obtained. This is evaporated to dryness, taken up in 100 cc. of water, and an excess of palladous chloride added. After the addition of one or two drops of dilute hydrochloric acid the whole is heated to boiling in a beaker.

The black palladous iodide is filtered off, using a vacuum filtering dome, an ordinary funnel, and hardened filter paper.

It is not necessary to remove all the iodide from the beaker, but after washing the beaker and the filter with water, the beaker is used as a receiver and the iodide on the filter dissolved with hot aqueous ammonia into the beaker.

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[3] Whitfield, J. E., *Am. Chem. J.*, 1886, viii, 421.

[4] Vortmann, *Z. Electrochem.*, 1895–96, ii, 314.

[5] Specketer, H., *Z. Electrochem.*, 1897–98, iv, 539.

[6] Smith, E. F., *Am. Chem. J.*, 1891, xiii, 206; 1892, xiv, 435.

[7] Smith, E. F., and Keller, H. F., *Am. Chem. J.*, 1890, xii, 212.

All the palladous iodide remaining in the beaker is carefully dissolved. For small weights of iodide the solution is electrolyzed directly; for larger ones it is first made up to a definite volume in a flask and then an aliquot part electrolyzed.

With a weighed gauze platinum cathode, the solution is electrolyzed in a platinum dish at a dilution of 60 cc. and at 65°C. About 1 cc. of ammonia is added. The current may vary from 0.5 to 1 ampere, the voltage from 5 to 10 volts. Rotating the cathode at about 300 R. P. M., the palladium is readily deposited.

The current is interrupted, the cathode carefully washed with water over the dish, then after removal of the cathode from the spindle of the rotator, it is washed with water, alcohol, and ether. After warming in an electric oven and cooling in a desiccator, it is weighed. About 25 minutes are required for the complete deposition.

The solution is evaporated to half volume, with the addition of 1 cc. of 10 per cent sodium hydroxide and 1 gm. of sodium potassium tartrate, and is covered with a watch glass.

After cooling and diluting to 40 to 50 cc., the iodine is deposited on the silver electrode as anode, the current having been reversed. The pressure should be 2 volts, current 0.01 to 0.05 amperes, and the anode stationary. Time required, 30 to 40 minutes. Stirring at this point seems to favor the detachment of silver iodide. After washing as above, the electrode is dried at 300°C. in an electric oven. It is cooled and weighed.

All reagents must be carefully examined for chlorides, and the silver is best purified by electrolysis.

Preparation of Electrodes.

The silver plated anode is prepared as follows: A circular platinum gauze electrode is heavily plated from a silver ammonium oxalate solution, using 1 to 2 amperes and 5 to 10 volts and rotating at about 300 R. P. M. This electrode is washed with ammonia water, distilled water, and ignited. It is then boiled with hot water for half an hour, washed in water, absolute alcohol, absolute ether, dried at 300°C. in an electric oven, and weighed.

After each determination the silver iodide is removed by cyanide and the washing repeated. An electrode lasts from six to twelve determinations before replating is necessary.

The platinum cathode (circular, gauze) is freed from palladium by dipping into a mixture of saturated salt solution and chromic acid. This scarcely attacks the platinum.

The following tables show values obtained by this method.

In Table I are the figures obtained by electrolyzing a portion of a standard solution of palladammonium iodide prepared from a standard solution of potassium iodide.

Table II shows values obtained by use of the complete method on some typical organic iodine compounds.

Table III shows a check on a series of determinations by the colorimetric method of the iodine content of tuberculous and normal tissues.

TABLE I.

	Iodine.	Palladium.
	mg.	*mg.*
Present......................	2.50	1.054
Found.......................	2.60	1.05
"	2.45	1.08
"	2.45	1.00

TABLE II.

Iodobenzoic acid 0.5 gm. taken. 51.21 per cent I. Dilution 500 cc.	Iodine.		Palladium.	
	Present.	Found.	Present.	Found.
cc.	*mg.*	*mg.*	*mg.*	*mg.*
1	0.512	0.50	0.216	0.20
5	2.56	2.50	1.08	1.10
10	5.12	5.08	2.16	2.11
Iodoacetanilide 0.5 gm. 48.65 per cent I. Dilution 500 cc.				
1	0.49	0.46	0.21	0.22
5	2.43	2.40	1.03	1.00
10	4.86	4.84	2.05	2.05
Diododiphenyl 0.5 gm. 62.56 per cent I. Dilution 500 cc.				
1	0.63	0.64	0.27	0.26
5	3.13	3.10	1.32	1.30
10	6.26	6.21	2.64	2.63

TABLE III.

Check on Twenty-two Colorimetric Determinations.

	Iodine.	Palladium.
	mg.	*mg.*
Colorimetric	7.016	Calculated..... 2.96
Electrolytic	6.90	Found......... 2.82

SUMMARY.

1. The electrolytic method may be used to estimate gravimetrically the iodine present in organic tissues or in organic iodides.

2. It provides an adequate check on a series of determinations by the palladous iodide colorimetric method.

3. In all cases the estimation of both cation and anion gives another check.

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FURTHER OBSERVATIONS ON THE PRESENCE OF IODINE IN TUBERCULOUS TISSUES AND IN THE THYROID GLAND.

BY PAUL A. LEWIS AND ROBERT B. KRAUSS.

(From the Henry Phipps Institute of the University of Pennsylvania, Philadelphia.)

(Received for publication, June 19, 1915.)

In a previous paper[1] we gave the results of some analyses which showed that the tuberculous tissue of rabbits might contain appreciable amounts of iodine, even though iodine products had not been administered to the animals.

The points made in that paper may be repeated here by quoting the summary there given, as follows:

> Tuberculous tissue derived from animals to which no iodine preparation has been knowingly administered may contain amounts of iodine very appreciably higher than normal control tissue of the same animal. While it is quite probable that tuberculous tissue in animals treated with iodine products may store up iodine, this has been by no means clearly shown in any experiments so far reported. The highest figures for the tuberculous tissue of untreated animals in our experience may equal the highest figures of those reported by others as evidence for the localization in the tissue of iodine intentionally administered.

The analyses on which this first paper was based were done by the Kendall method. It was understood by us that this method was scarcely adequate to give perfect results with the small amounts of tissue available for study. Objections reached us from those who believed that the method was entirely inadequate and that consequently it was unlikely that our results represented the true situation.

Accordingly one of us (Krauss) has devoted considerable effort during the past winter to the development of more accurate and sensitive methods for the examination of tissues for iodine. This study has been entirely successful and a method is now available which is competent to detect with certainty and measure with accuracy the merest traces of iodine.[2]

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[1] Lewis, P. A., and Krauss, R. B., *Jour. Biol. Chem.*, 1914, xviii, 313.

As in the older methods, the dried tissue is subjected to a process of incineration to convert the iodine into an inorganic form. Palladium chloride is added to an extract of the fusion mass and in the presence of iodine develops palladium iodide, which gives a characteristic color reaction. The intensity of the color developed is determined by colorimetry in comparison with standard solutions.

Using this method for the examination of the tissues for iodine we have reexamined the points at issue. Our work has been conducted as follows. Rabbits are inoculated on the cornea of one eye with a virulent culture of the tubercle bacillus of bovine type. This gives a rapidly progressing infection the characteristics of which we have previously described in detail.[3] At suitable intervals the animals are killed. The corneas are dissected free from the remainder of the eyes. The tissues are separately dried and analyzed for iodine. We have in this way for analysis, first, the tuberculous cornea; second, the normal cornea of the same animal; third, the remainder of both eyes; and fourth, any other normal tissue from the animal which it may be useful to examine. The thyroid gland has been included in this series in most instances. If the animals are allowed to live long enough of course the disease becomes generalized and tuberculous tissues from other parts of the body may also be examined.

The results of these experiments are presented in the following tables. The figures give the amount of iodine found in mg. per gram of dry tissue.

In Table I are collected the figures from the experiments which were carried through in exact accordance with the outline just given. The following points may be developed from these results.

The normal cornea frequently contains appreciable amounts of iodine. In animals in which this is the case tuberculous tissue arising on the opposite cornea also contains iodine, and this, so far as our results go, in relatively larger amounts. The remaining tissues of the eye usually contain no iodine. Certain exceptions to this appear in the results, Nos. 1180, 1054, 1194, 734. It is most probable that these exceptions are due to the fact that after several weeks the disease spreads from the cornea to the conjunctiva and gradually to the deeper structures of the eye. At this time the removal of the diseased tissue with the cornea is not complete. The proper procedure in these instances would be to examine the bulbar portions of the opposite eyes separately. This was done only once in our series, No. 734. In that case it appeared that the iodine in the bulbar portions occurred only in the infected eye.

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[2] Krauss, R. B., *Jour. Biol. Chem.*, 1915, xxii, 151.

[3] Lewis, P. A., and Montgomery, C. M., *Jour. Exper. Med.*, 1914, xx, 269.

It will be noticed that the amount of iodine in the tuberculous tissue or in the normal cornea bears no direct relation to thyroid iodine. The latter is high, low, or entirely absent in instances in which the iodine in the eye is about the same, Nos. 1187, 1205, 1194.

TABLE I.

Rabbit No.	Days lived.	Normal cornea.	Diseased cornea.	Thyroid.	Remainder of both eyes.
		mg.	*mg.*	*mg.*	*mg.*
1149	19	0.000	0.000		0.000
1152	19	0.3	5.50		0.000
1172	22	0.000	0.000	0.000	0.000
1180	26	0.000	0.000	0.000	0.086
1205	30	0.0876	0.1805	0.09	
1187	35	0.0826	0.1232	0.9301	0.000
1181	37	0.0960	0.1320	0.0476	0.000
1198	37	0.085	0.178		0.000
1054	37	0.0730	0.3384	0.0476	0.1178
1194	37	0.085	0.186	0.000	0.002
734	37	0.0620	0.2016	0.060	Left 0.025 Right 0.000

The results in Table II are intended to furnish additional evidence that tuberculous tissues may contain iodine. In these instances the disease of the eye had advanced so far that it was impossible to separate the tuberculous from the normal tissue. The whole eye was examined in comparison with the whole of the normal eye. These results agree in essentials with those presented in Table I. The amount of tissue examined is much larger and the relative difference in weight much smaller than in the first instances. This of course tends to equalize the figures for iodine as expressed in mg. per gram.

On the basis of our results as presented in Tables I and II as well as those of our previous paper it might have appeared possible that the tuberculosis of the cornea was a special case whose results would be without general application. Especially was this so in view of the fact that we have so often found iodine in the normal cornea, the fundamental tissue of the experiment. In Table III, therefore, we present a few analyses of the caseous lymph nodes of animals, four guinea pigs and one rabbit, suffering from more or less advanced generalized tuberculosis. The amount of iodine contained in this material is also far from negligible.

TABLE II.

Rabbit No.	Days lived.	Normal eye.	Diseased eye.	Thyroid.
		mg.	*mg.*	*mg.*
1182	56	0.000	0.030	0.222
1197	56	0.0312	0.0326	0.1390
1191	56	0.0100	0.0189	0.0700
1175	56	0.0070	0.0231	0.0159
1151	56	0.004	0.021	0.061

TABLE III.

Animals.	Material examined.	Iodine per gm.	Duration of disease.
		mg.	
Guinea pig 1437	Caseous nodes	0.000	Died in 1 mo.
" " 1434	" "	0.062	Killed in 1 mo.
" " 1312	" "	0.424	Killed in 1 mo.
" " 1403	" "	0.160	Killed in 5 weeks.
Rabbit 1151	" "	0.0132	Killed in 56 days.

The analysis of the thyroid gland requires some separate comment. In a recent review of work on the iodine content of the thyroid, Cameron[4] cites the work of various observers who have analyzed the glands from certain individuals with negative results. He emphasized the probability that iodine is always present, but in amounts not detectable by the methods employed previously, making the following statement in italics. "No stress can be laid on any negative results so far published until they have been confirmed by an accurate method such as that of Hunter."

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[4] Cameron, A. T., *Jour. Biol. Chem.*, 1913-14, xvi, 465.

Our results indicate most clearly that iodine, if indeed it is always present, is at times not to be demonstrated by a method considerably more sensitive than any previously employed. Some of the earlier observers have believed that young animals were more apt to give negative results. The animals in our series were adults, several of them known to be more than one year old. We have examined the thyroids microscopically without being able to see the slightest difference between those containing iodine and those in which we could not detect this element.

We conclude from this work that iodine is frequently present in tuberculous tissue independently of any intentional administration of iodine-containing substances. The quantities found are such as to lessen the force of the conclusion of previous observers that the tuberculous tissue has an especial affinity for iodine when intentionally administered. This may of course be the case, but the evidence for it is so far insufficient. We have no evidence bearing on the nature of the iodine compounds in the tuberculous tissue or the source from which they are derived. The iodine is, however, independent of thyroid iodine in its quantitative relationships.

The thyroid gland of rabbits may at times be free from any appreciable amount of iodine.

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THE DISTRIBUTION OF TRYPAN-RED TO THE TISSUES AND VESSELS OF THE EYE AS INFLUENCED BY CONGESTION AND EARLY INFLAMMATION.

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It is the purpose of this paper to present certain simple observations which have a bearing on the manner in which the constituents of the aqueous humor are secreted into and eliminated from the anterior chamber of the eye. It will be shown that external influences may affect profoundly the ease with which abnormal constituents appear in the anterior chamber fluid. The observations have some bearing on general problems of pathology and pharmacology which will be pointed out. And lastly there will be included some observations on the diffusion of substances into and from the cornea.

All the observations have been made on the rabbit's eye. The azo-dye trypan-red as furnished by Grübler has been the substance chiefly employed for testing the permeability. This dye has been dissolved in normal saline solution to the amount of one-quarter of 1 per cent. 100 cc. of this solution may be warmed to body temperature and injected slowly into a full grown rabbit by the intravenous method without causing the animal any immediate distress and with no appreciable evidence of toxicity later. Under these circumstances by the time the injection is finished the skin and mucous membranes of the entire body are stained red. The intensity of the stain in the tissues increases for a number of hours to a maximum which is maintained without appreciable change for a number of days, and which then gradually fades out over a period of weeks and months. Trypan-blue and other azo-dyes of similar physiological activity may be used in the same general way.

Trypan-red is a colloidal substance; that is, its watery solutions do not diffuse through parchment paper. When, therefore, the dye leaves the blood vessels to appear in the tissues, the lymphatic spaces, lachrymal secretions, or the urine, its passage is in itself evidence that the interposed tissue surfaces are not perfect dialyzing membranes. They are either leaky mechanically to substances of certain physical constitution, or they exert a selective action which permits some colloids to pass while retaining others.

If the normal eyes are observed at any time after the injection of the dye in the manner described it will be seen that the sclera shares the stain of the skin with greater or less intensity. No stain can be detected in the cornea or anterior chamber fluid by inspection of the eye. If, however, after a number of hours the aqueous humor be withdrawn it will be found to have a barely appreciable pink color. If at the end of a week or 10 days the animal is killed, the eye removed, and the cornea dissected free, it also will be seen to be stained very faintly although definitely. If the blood be withdrawn immediately after the injection, the serum is found intensely stained with the dye. As the tissue stain increases in intensity, the stain disappears gradually from the blood to a minimum point which is probably long maintained.

Observations on the Aqueous Humor.

If within a few minutes after finishing the intravenous injection one eye is cocainized and the anterior chamber fluid withdrawn, a colorless fluid is obtained. As the chamber refills, which it does in the course of a short time, the reformed fluid is stained intensely. The rapidity with which a stained fluid appears in the anterior chamber following such a tap varies considerably in different rabbits. It is also possible so to alter the physiological condition of the eye that the dye when injected intravenously will quickly appear in the anterior chamber without the preliminary tapping.

With the facts above outlined as a basis for work, experiments have been carried out which throw some light on two distinct questions; namely, the place from which certain abnormal constituents may be secreted into the anterior chamber of the eye, and secondly the relation between the different constituents of an altered anterior chamber fluid in the time of their appearance.

There is now a general agreement that the normal anterior chamber fluid is furnished from the vascularized ciliary body behind the iris, reaching the anterior chamber through the pupil. No experiment entirely free from objection has ever been devised either to prove or disprove this. The experiments in proof of the proposition have involved the withdrawal of fluid from the eye, a procedure which at once disturbs the relationships to an important degree. The experiments of Ehrlich[1] with fluorescin were interpreted by him to signify that the anterior chamber fluid was secreted from particular regions of the anterior surface of the iris. Ehrlich's experiments, done many years ago in part, show that fluorescin appears in the anterior chamber fluid from regions anterior to the iris. It should be recognized, however, that in interpreting such an experiment the fluid and the various other elements of either a normal or an altered aqueous humor may originate in different places. Those portions of Ehrlich's experiments which seemed to him to show that there were definite currents in the aqueous humor flowing from the sides toward the center, meeting on a vertical line in the midregion of the chamber in such a way as to form a swirl where the two streams meet, are susceptible of no explanation in the light of the conditions, as displayed by our work with trypan-red.

When the aqueous humor is withdrawn the pupil usually contracts more or less. Almost immediately the chamber begins to fill again with fluid. When the tap has followed shortly after the intravenous injection of trypan-red, the reformed fluid, as has been said before, is colored with the dye. The color comes for the most part through the pupil from behind. Occasionally it can be seen that the dye makes its appearance in considerable concentration on the anterior surface of the iris away from the pupilary margin before any color has appeared through the pupil.

If eserine is dropped in one eye in sufficient quantity to contract the pupil as far as possible, and if then the dye is injected intravenously, even though no aqueous humor is withdrawn the fluid will frequently become colored. Here again the color always appears from behind the pupil, but it may also appear on the anterior surface of the iris independently.

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[1] Ehrlich, P., Ueber provocirte Fluorescenzerscheinungen am Auge, *Deutsch. med. Wchnschr.*, '882, viii, 21.

Neither cocaine nor atropine causes the appearance of color in the untapped eye. Atropine when used in such a way as to dilate the pupil fully before the eye is tapped prevents any appearance of dye on the anterior surface of the iris.

If one eye of a rabbit is cocainized and the cornea inoculated with a living culture of the tubercle bacillus, a progressive lesion results, differing in character with the particular culture used and the amount inoculated. The characteristics of this lesion we have described in detail elsewhere.[2] 24 hours after the inoculation there is usually an intense congestion of the conjunctiva, the iris and the ciliary body being more or less congested. This congestion tends to subside by the 2nd day but does not, as a rule, entirely disappear.

24 hours or more after such an inoculation, if the animal is injected with the dye intravenously as above described, the anterior chamber fluid of the inoculated, untapped eye will always become colored. Here again most of the color appears through the pupil, but in many instances it also appears earlier and independently on the anterior surface of the iris.

In each of these instances, the tapped eye, eserinated eye, or the tubercular eye, whenever the color appears on the anterior surface of the iris, it seems to be associated with definite areas of congestion. It would be interesting to know whether it is impossible to have the color appear abnormally in the absence of such a congestion. We have, with this in mind made some experiments with abrin. This poison, as is well known, causes an intense inflammation of the conjunctiva when it is dropped in the eye. The inflammation is characterized by a well marked edema and congestion and develops slowly through a stage which is, generally speaking, one of edema, to a stage which is more predominantly congestive. In the various stages of this inflammation trypan-red or trypan-blue applied intravenously appears in the anterior chamber, and in the edematous conjunctiva with unusual rapidity. We have never had a result, however, which enables us to think that the dye can appear in abnormal amount or situation as a consequence of an edematous condition alone and in the entire absence of congestion.

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[2] Lewis, P. A., and Montgomery, C. M., *Jour. Exper. Med.*, 1914, xx, 269.

To sum up this portion of our remarks we may say that under conditions in which the eye is slightly congested certain dyes injected intravenously may appear in abnormally large amount and with unusual rapidity in the aqueous humor. The largest amount of the dye comes into the aqueous humor from behind the iris, but appreciable amounts frequently come from the anterior surface of the iris. In these instances the iris has always shown a local congestion in the region in which the dye has appeared.

It is a well known fact that if the aqueous humor be withdrawn the fluid which refills the anterior chamber differs from that first withdrawn in that it coagulates spontaneously. We have tested the relationship between the appearance in the fluid of the factors controlling the coagulation and the dye. When the dye is injected intravenously, the eye being tapped at once after the injection is finished, the rapidity with which the dye appears in the anterior chamber varies greatly in different rabbits. It is usually from 20 to 30 minutes before fluid is obtained which would be classified as intensely stained. At this time the fluid has always coagulated spontaneously in our experience. Occasionally we have had animals in which at the end of 5 minutes the anterior chamber fluid was intensely stained. On withdrawing this at once we have several times obtained an intensely colored fluid which did not coagulate. These facts suffice to show that the appearance of the dye is independent of the appearance of at least some of the factors determining coagulation.

The distribution of the dye when it comes into the anterior chamber is interesting in that it throws some light on the rapidity of movement of the aqueous humor. In those instances where the dye appears in concentration on the iris surface before it comes through the pupil it diffuses very slowly from the point where it makes its appearance, and this diffusion is apt to be more or less even in all directions. When the dye comes through the pupil it is apt to come over the lower pupilary margin in a concentrated stream which sinks slowly to the bottom of the chamber and from there, spreads in the course of half an hour or more by diffusion until the aqueous is evenly colored.

The conditions can easily be duplicated outside the body. If one takes a thin collodion sac about an inch in diameter, fills it with a 1 per cent solution of trypan-red, and gently lowers it into a beaker of water the dye will diffuse out of the sac into the water with moderate rapidity. The dye comes out of the sac over the entire submerged surface. It then apparently creeps along the surface of the sac to the lower end of it and falls from there in a narrow stream of concentrated dye to the bottom of the beaker. It spreads along the bottom to make a concentrated red layer in this region. Then in the course of an hour or more it diffuses throughout the water. If the beaker is disturbed, of course the secondary spread is hastened.

The conditions in the anterior chamber of the eye are analogous to this, and it is hard to reconcile the observations with the view that there are any very active movements in the aqueous humor. There seems to be a tendency for matter coming into the anterior chamber through the pupil, to come in at the lower margin and to sink to the bottom of the chamber.

There is also a tendency for the dyes that we have used, at least, to leave the chamber in a definite region. If 0.5 cc. of a 1 per cent solution of trypan-red or trypan-blue is taken in a suitable syringe and the aqueous humor from a normal eye is also drawn into the same syringe and if then the mixed fluid and dye solution is immediately reinjected, care being taken to restore approximately the original tension, the absorption of dye can be watched very well. Within a few minutes vessels in the sclerotic will be seen to be injected with the dye. The vessels which are first injected and the only ones which usually show a pronounced injection are on the upper surface of the eyeball to each side of the midline. The injection of vessels in this region persists until the dye is completely absorbed.

The indication in these experiments is, then, that there is very little movement in the aqueous humor. The points of secretion and absorption are such as to determine fairly definite lines of diffusion for colloidal matter in the fluid, which in a general way are from behind the iris, through the pupil to the lower portion of the chamber, and then upward to leave at the superior portions of the angle.

Observations on the Cornea.

In a preceding paragraph we said that a number of days after an intravenous injection of trypan-red the cornea becomes distinctly colored. It is the generally accepted view that substances which reach the cornea do so by diffusion from the corneoscleral margin. The way in which the cornea becomes stained is in accord with this. If an animal is killed 2 or 3 days after the dye is injected, the cornea will, on examination, be found stained at its circumference, the colored area at this time reaching about one-third of the way to the center.

In connection with the study of experimental tuberculosis previously referred to, we observed that the reactions of the cornea were not uniform throughout. If, for example, a central inoculation is made, the first formation of blood vessels at the corneoscleral margin will be above, at approximately the midline. Next, vessels will form on the midline below, and, lastly, on the sides. We assumed that this was because substances diffused out of the cornea by preference toward the upper portion and hence stimulated the tissue reactions first at that point. That the diffusion is along these lines we have now found can be shown to be the case with the dyes we have used in this work. If the cornea is infiltrated in a spot 2 to 3 mm. in diameter at its center, the dye does not diffuse toward the lower corneoscleral margin in any appreciable degree. The diffusion is chiefly toward the upper margin, spreading out more or less in the shape of a fan in this direction. To get a diffusion chiefly toward the sides or lower margin it is necessary to place the infiltration quite close to the corneoscleral junction in those directions.

SUMMARY.

In as far as the observations reported have a bearing on the movements of fluid within the eye, they are, for the most part, in accord with views at present generally accepted. On the other hand, we know of no other way in which it may be so readily demonstrated that simple and even temporary local circulatory changes may profoundly alter the distribution of substances from the circulating blood to the extravascular fluids and tissues. In the light of these observations, it would seem that such changes might easily account for marked idiosyncrasies in the action of poisonous drugs, and as well probably for other factors in drug action.

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OBSERVATIONS BEARING ON THE POSSIBILITY OF DEVELOPING AN EXPERIMENTAL CHEMOTHERAPY OF TUBERCULOSIS.*

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It is a matter of record that, directly after his discovery of [120] the tubercle bacillus, Koch devoted a great deal of attention to efforts to cure experimental tuberculosis in animals. Cornet,[1] then an associate of Koch, records the negative results of experiments with a certain number of drugs and chemicals in this endeavor.

The experiments made in this earliest work on the experimental therapy of tuberculosis naturally rested in large part on an empirical basis. The hope that an effective method of treatment could be arrived at in this way was based on no precedent. The materials chosen were naturally those that had some reputation as active agents in the treatment of tuberculous lesion in human beings.

It was a matter of course that a mind as logical as Koch's should have demanded the development of some more scientific basis for further experimentation. He proceeded on the tentative assumption that, if substances could be found with the capacity to check the growth of the tubercle bacillus in the culture flask, there might be those among them which would likewise restrain the proliferation of the parasite in the animal body. He accordingly carried out experiments with a large number of substances to determine their capacity to inhibit the growth of cultures. These experiments were not reported in any detail, either as to the precise methods employed or as

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* Read before the Laennec Society, at The Johns Hopkins Hospital, March 27, 1916.

[120] to the quantitative aspects of the results attained. Koch[2] states that the following substances were especially active *in vitro:* "A number of ethereal oils, among aromatic compounds β naphthylamin, para-toluidin, xylidin; some so-called tar colors, namely fuchsin, gentian violet, methylen blue, [121] chinolin yellow, anilin yellow, auramin; among the metals, mercury in vapor form, silver and gold compounds. Gold-cyanogen compounds are especially striking in their surpassing activity over all other substances." Further: "All of these substances remained completely inactive when tested on the tuberculous animal."

In the course of these experiments it was found that a certain substance which could be extracted from the growing cultures was capable of profoundly influencing the progress of experimental tuberculous disease in guinea-pigs when administered to them during its course. In the first experiments the influence seemed to be of a curative nature and the substance, known at first as "Koch's Lymph," later as "tuberculin," was introduced into medical practice. What may be called the physiological activity of tuberculin is now a matter of common knowledge. Whether this activity can be so applied that the substance can be considered a useful therapeutic agent has been from the very beginning a matter of violent and almost fruitless controversy. As I have already pointed out elsewhere,[3] any evidence which may be in favor of the usefulness of tuberculin in practical therapy is derived from clinical observation. This question is raised, not because it directly concerns the matter in hand, but because it is apparent that, as a matter of history, the discovery of tuberculin, the violent controversy that it excited and the brilliant discoveries in the field of serum therapy which followed so soon after, caused this early experimentation with well-defined chemical substances to be abandoned and for the time forgotten.

Then followed a period of 15 years, during which no observations of any interest in this field were recorded. Those interested in the disinfectant activity of various chemicals frequently included the tubercle bacillus in their lists of microorganisms tested. The methods employed were not uniform and the chemicals were selected according to no general plan.

As the chief result of present interest in the scattered work of this period, it has come to be recognized that the tubercle bacillus, as contrasted with other common pathogenic bacteria, is difficult to kill with chemical disinfectants. In this period there should be noted the paper of Boer[4] on certain aspects of the activity of disinfectants. Working with a number of non-related substances, he found that there were certain differences in the intensity of the action of various substances against cultures of non-related species of bacteria. [121]

This concept was developed further and practically applied to the differential cultivation of more closely related species by Loeffler, Conradi, and others. It was found that various anilin dyes, malachite green in the first instance, cresyl violet, crystal violet and basic fuchsin in later cases, markedly check the growth of *B. coli* or various troublesome micrococci in concentrations which do not inhibit the growth of *B. typhosus.*

To substances showing this type of differential activity Bechold and Ehrlich[5] applied the term partially-specific (halbspecifische) disinfectants in contradistinction to the more highly specific bacteriolysins of the blood serum of immunized animals. These authors applied the highly complicated methods of synthetic organic chemistry to the development of a series of closely related chemical compounds whose disinfectant activity they then studied from this point of view. Their studies revealed the most striking examples of this partially specific disinfectant action. For instance, tribromnaphthol was found to possess a very strong disinfectant action against staphylococci, streptococci and diphtheria bacilli, very little against *B. pyocyaneus* and none at all against the tubercle bacillus. Monochlornaphthol is more active against staphylococci than cresol, but far less active than tribromnaphthol. Against the pyocyaneus and the tubercle bacillus, on the contrary, monochlornaphthol is very active.

The early efforts of Ehrlich to develop chemotherapeutic agents for use in experimental trypanosomiases were much influenced by the thought that test-tube study of the disinfectant action of substances against the parasite could be used as a clue to the chemicals which it would be profitable to study subsequently in animal experiments. The expectation, in these

[121] instances, proved without foundation and in fact the substances more active *in vivo* often had very little activity in the test-tube. It would probably be short-sighted to conclude from this experience in a very special field that test-tube results could never be useful as a guide. And in fact, the recent observations (after the fact, so to speak) of Schiemann [6] show that salvarsan, inactive in the test-tube against protozoa, but very active in the body, is active in the partially specific sense against certain bacteria, both in the animal body and in the test-tube.

The hope, so evidently entertained by Koch, that it would be possible to develop in a rational way specific chemical agents to cure particular diseases (tuberculosis first of all in his mind), fulfilled in the most spectacular way by Ehrlich at a time when it had been abandoned as a moving conception in the minds of most workers, has again become a dominating factor in many laboratories where tuberculosis is a subject of study. The general considerations which must be taken into account when the principles developed by Ehrlich are applied to the study of tuberculosis have been well stated and at length by Wells [7] and his associates, and need not be further discussed here. We reiterate, for the sake of emphasis only, that the methods of handling tuberculosis experimentally and the conception that it might be possible by systematic search to find a rational treatment we owe to Koch. The model for such a search, the realization of the vast labor by a highly complex organization which must be contemplated as probably essential to achievement, and finally, the demonstration that for one radically different but equally tenacious disease (syphilis) success along these lines is possible, we owe to Ehrlich.

It may be profitable to consider briefly in more detail what is involved if we are to try, with hope of success, to apply the principles of Ehrlich to tuberculosis research. In the first place, Ehrlich's success was in no small measure due to the fact that he had to deal with experimental diseases whose course was rapid and whose limitations were very precise. From the time of infection to certain death in the untreated animal was in his typical case three or four days, and the exact condition of the animal could be determined at any moment by a simple examination of the blood. In our case we have no such favorable basis for experimentation. In laboratory animals infected with properly selected cultures, death is certain, but the length of life is very uncertain except after most overwhelming doses, and I know of no experiment which can be terminated in less than a month. Many require much longer before an interpretation is possible. [122]

Before this Society, four years ago, I reported observations on experimental tuberculosis of the cornea made with the cooperation of Dr. Montgomery,[4] which we hoped would give a good basis for therapeutic tests. This lesion is useful for the study of certain features of the disease but fails in other very important particulars. Much further work is needed to develop conditions under which the generalized disease or local lesions will run a precise and invariable course. It is not to be expected that high speed will be attained, but the shorter the course the more useful will be such a reaction as a basis for work.

On the other hand, tuberculosis is a field of study offering certain distinct advantages. The bacteria are demonstrated in the tissues with comparative ease and certainty; in the tissues they cause a very distinct local lesion; and the distribution of certain chemicals to this diseased tissue can be very precisely followed.

This last factor, the distribution of drugs to the tissues, has been the starting-point for a number of recent researches, and for some premature efforts in the treatment of the human disease. Our own recent work has been very greatly influenced by the observation that certain anilin dyes, when injected into the living tuberculous animal, become concentrated to a considerable extent in the diseased tissues. On the occasion of a visit to Baltimore four years ago, to attend a meeting of the Society, I was shown some very beautiful preparations by Dr. Winternitz, preparations made in a study of the origin of the cells taking part in the reaction of the earliest hours after an infection of the animal with tubercle bacilli, and since carefully described by Bowman, Winternitz and Evans.[5] My interest was aroused in the possibility of making a wider application of the so-called vital stains, and I soon found by experiment that the fibrocaseous tubercle took up these stains in a char-

[122] acteristic way. The results of these early experiments were recorded and summarized in the following terms:[10]

> **The first of these experiments shows again the selective action of Isaminblau for the large mononuclear phagocytic cell as pointed out by Goldman. These cells are found abundantly in the peripheral portions of fibroid tubercles.**
>
> **The second experiment is of great interest, showing, as it does conclusively, that extraneous chemical substances of proper constitution may within a few days penetrate to the caseous center of a tuberculous mass and become concentrated there in greater degree than in the normal surrounding tissues. The particular substance used in this experiment, Trypan-rot, may probably be without effect on the lesion itself, but the result should be a great stimulus to future work in a similar direction.**

These experiments have seemed to us of the utmost importance as a basis for further experimental work of a co-ordinated chemical and biological nature. The opinion had been quite generally expressed that, since the tuberculous tissue was without an internal blood supply, it could be reached only with difficulty, if at all, by medicinal agents which might be made to circulate in the blood stream. Such an opinion, if of decisive weight, would make it appear to be an unreasonable waste of time to experiment to any great extent with the idea of developing general medicines that might be hoped to influence the local tuberculous process. The actual result, on the contrary, rendered such experimentation reasonable and, as it seemed to us, eminently desirable.

Before dealing in greater detail with our subsequent work on this subject, I wish to refer briefly to certain observations of others. Independent observations by De Witt[11] in this country and by von Linden[12] in Germany have shown that when methylene blue, or any one of several of its modifications, is introduced into the living diseased animal, the leuko-base of the dye is to be found in the caseous portions of the tubercle. Since methylene blue strongly restrains the growth of the tubercle bacillus outside the body (von Linden claims that the leuko-base is more strongly germicidal for the tubercle bacillus than the dye itself), and since, moreover, von Linden asserts that the tubercle bacillus is stained in the lesions, it would seem that nearly all the desirable qualities that could be postulated for the object of our search are possessed by this dye.

Suffice for the moment to say that the work of von Linden is [122] considerably offset by criticisms offered by her colleagues and former associates, and that De Witt's results are not in accord with it in many important particulars. For the past four years the work of Dr. De Witt and Dr. H. J. Cooper in the laboratories of the Sprague Memorial Institute, Chicago, under the direction of Dr. H. G. Wells, has followed the same general course as the work in the laboratories of the Phipps Institute. As we have used quite different materials, the two series of researches are to be considered as complementary.

Returning now to the progress of our own experiments, I would call your attention to the obvious, and say that the further development of such a subject as this is dependent on the pursuit of both chemical and biological studies in a carefully co-ordinated way. I have been fortunate in having as an associate Mr. R. B. Krauss, and throughout the rest of the paper, whenever points involving chemical manipulation are referred to, the work is to be credited to him.

The first concrete problem outlined on the basis of the above experiments was to take the dye "Trypan-rot," which had been used in the more striking of the experiments above commented on, and try by chemical manipulation to form from it or with it a substance having physiologic activity while preserving the qualities which enabled the dye to penetrate the tubercle.

Mr. Krauss undertook to make as many modifications of trypan red as he could, following certain general lines.

1. The staining qualities of the substance were to be at least in part preserved.

2. The preference was to be given to substances containing iodine, phenolic substances, or certain other constituents.

These specifications were drawn up on very general grounds, some of which may be stated as follows: Iodine was selected because of the long-standing belief among medical men that [123] iodine had some influence unfavorable to the progress of tuberculosis when applied locally either as an element or as iodoform; carbolic acid, guiacol and other phenolic substances were known to be relatively active disinfectants against the tubercle bacillus, and some of them also enjoyed a reputation as medi-

[123] cines for this disease. The staining qualities were to be preserved as far as possible as a guide to the localization in the course of the subsequent animal experimentation.

The chemical work was successful. In the course of a year and a half about 75 compounds were secured on the plan outlined. The chemical manipulations and results have been published by Krauss.[13] These preparations were used in a preliminary way in animal experiments, and some interesting observations were made. In general it was indicated that none of the substances exerted any curative influence on experimental tuberculosis. Some of them seemed, however, to have a definite influence on the vigor and rate of the formation of blood vessels and connective tissue in and around the tuberculous process; the tests being made on the cornea of the rabbit.

The plan had been to prepare enough of each substance for a moderate amount of preliminary experimentation and then to make some more of those which seemed useful for further work. About the time the preliminary study of these compounds was completed, the war began and necessitated a change of plan. We had been purchasing trypan red from abroad and a further regular supply was unobtainable. What was on hand and the occasional lots since secured we have used in a study of the composition of the substance with view to its manufacture.

Trypan red was first made for Ehrlich and was assigned a definite chemical formula by him, presumably based on the method of manufacture. On the basis of this formula the manufacture of the substance should be relatively easy, but we have not succeeded in carrying it out. On the contrary, we have been able to show that the trypan red of the German market does not agree with its constitution as given by Ehrlich. Only by continued analyses can we hope to learn how to make the substance. Under the present circumstances the work we have done in this particular field cannot be used to advance the subject until we are able to repeat our experiments with certain of the preparations and do it in such a way that they may be susceptible of repetition by others. I have reason to believe that these difficulties will be overcome in due time. We have meanwhile been searching for some other substance which might have the essential properties of trypan red and which at the same time could be made by us.

Following our observation that the tuberculous tissue in [123] the living animal was easily penetrated by trypan red, many other dyes of the same general class, chemically speaking, were tested for their reaction in this particular. A considerable number were found which could become concentrated in the diseased tissue to a greater or less extent. Many of these had never been accurately described from a chemical point of view; others presented difficulties in manufacture beyond our means. After much consideration, a dye known to the trade as Niagara blue 2B (Benzidin + 2 H. Acid) was chosen as the starting-point of a second attempt to construct a series of iodine and phenol compounds. Owing to the state of the chemical trade it has been necessary for us to build up this substance from the raw products. This has now been accomplished on a scale adequate for the purposes of our work, and we have recently had available a small series of finished compounds for further biological study. It is unlikely that these substances will replace those made with trypan red, but they are fully as likely to be instructive, and we now have the assurance of a solid foundation for the work.

Covering about the same period of time as these studies on the relation of the vital stains to the diseased tissue, and in the hope of acquiring information which should in some measure guide that work, we have been studying the disinfectant action of various substances for the tubercle bacillus. We have hoped to discover more substances having the partially specific action discussed in the earlier paragraphs of this paper. Much time has been spent over methods. The procedure by which the results here reported were obtained was to determine the least concentration of the substance in glycerin-bouillon which would definitely inhibit the growth of the tubercle bacillus. For comparison, from the side of the bacterial species we have used so far chiefly the typhoid bacillus, determining in the same way the concentration of the substance required to prevent its growth in the same medium.

Because of the relation to the work outlined in considering the subject of the vital stains, we have so far paid particular attention to anilin dyes. We have also considered the more common disinfectants and certain substances which are used in the building up of dyes.

[123] Certain rather striking observations have been made, which may be briefly recorded here. We hope to publish shortly a report covering the examination of several hundred substances by this method.

I. PHENOL (CARBOLIC ACID).

Concentration.	Typhoid Bacillus.	Tubercle Bacillus.
1/800	No growth	No growth
1/2000	Good growth	No growth
1/4000		Good growth

II. RESORCIN.

Concentration.	Typhoid Bacillus.	Tubercle Bacillus.
1/1000	No growth	
1/2000	Good growth	No growth
1/4000	Full growth	Mod. growth
1/20,000		Good growth

III. No. 158—BROWN DYE MADE BY COUPLING BENZIDIN AND RESORCIN.

Concentration.	Typhoid Bacillus.	Tubercle Bacillus.
1/200	Mod. growth	
1/400	Full growth	
1/20,000		Very slight
1/40,000		Mod. growth
1/100,000		Mod. to full growth

IV. ACRIDIN ORANGE. (DYE WITH ACRIDIN AS A BASE).

Concentration.	Typhoid Bacillus.	Tubercle Bacillus.
1/2000	No growth	
1/4000	Full growth	
1/100,000		Slight growth
1/200,000		Mod. growth
1/400,000		Full growth

[124] V. HELIOTROPE (KALLE & CO.) (A DYE RELATED TO SAFRANIN).

Concentration.	Typhoid Bacillus.	Tubercle Bacillus.
1/1000	No growth	
1/2000	Very slight	
1/4000	Mod. growth	
1/10,000	Full growth	
1/400,000		No growth
1/1 million		Mod. growth
1/2 million		Mod. growth
1/4 million		Full growth

Taking from these tables the concentrations at which the effect on growth appears to be equal, and considering the susceptibility to the action on the part of the typhoid bacillus as unity, the following figures for the susceptibility of the [124] tubercle bacillus are obtained:

Phenol. Typhoid 1/800 = T. B. 1/2000 or susceptibility of T. B. = 2½.

Resorcin. Typhoid 1/4000 = T. B. 1/100,000 or susceptibility of T. B. = 25.

No. 158. Typhoid 1/400 = T. B. 1/100,000 or susceptibility of T. B. = 250.

Acridin Orange. Typhoid 1/4000 = T. B. 1/400,000 or susceptibility of T. B. = 100.

Heliotrope. Typhoid 1/1000 = T. B. 1/400,000 or susceptibility of T. B. = 400.

These striking instances serve to illustrate the simplest phase of the problem. The data so far collected for consideration make certain more general statements possible.

(a) Of the anilin dyes, this partially specific activity is manifested quite generally by those related to safranin and to acridin. It is shown in greater or less degree by many of the azo-dyes made with benzidin as the basic constituent. On the whole the number of substances showing this property is large rather than small.

(b) Although in the studies previously made with other bacteria, the concentration required to inhibit the growth of the culture is roughly proportional to the higher concentration required to kill the microorganism in a short period of time, with the tubercle bacillus this is not the case. So far we have discovered no substance by which the tubercle bacillus is killed more readily than is the typhoid bacillus, and while we have used the term "partially specific disinfectants" in recognition of the work of others along similar lines, it would be more nearly correct to speak of partially specific inhibitors of growth.

(c) The ability to inhibit the growth of the tubercle bacillus in cultures is not dependent on high disinfectant activity in general, and is an attribute of a number of substances which are relatively non-toxic for higher animals.

In conclusion, I feel that the results described in the preceding pages form a substantial foundation for future work. With the localization of the dyes in the centers of the masses of tuberculous tissues and in certain cells in the peripheral

[124] portions of the same, the problem of distributing extraneous chemical substances to the diseased tissues was solved in its grosser aspects. It is equally clear that relatively non-toxic substances may be very active in restraining the growth of the tubercle bacillus outside the body. It may be predicted with a fair degree of assurance that there will soon be at hand a number of substances which can be concentrated in the diseased tissue, and which will at the same time possess in considerable degree the ability to restrain the growth of the tubercle bacillus in cultures. This we are disposed to think will mark a distinct step in advance toward the solution of the abstract problems involved in the development of a specific therapy for tuberculosis as contrasted with our position of five years ago.

Will it mark a long step toward the practical treatment of tuberculosis? It is unlikely. There is still no scientific observation to guide us further toward a substance having these qualities and also capable of coming into effective contact with the tubercle bacillus in the body tissues and fluids, considered minutely.

It should also be fully recognized by everyone concerned that the practical problem of treating tuberculosis may be a far more difficult thing to accomplish than its laboratory prototype. Certainly it will be a most unfortunate thing for the progress of tuberculosis research if every substance showing interesting properties in the laboratory is immediately rushed to the clinic regardless of consequences. In this situation, patience is to be taken more than usually as an evidence of virtue.

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DISCUSSION.

Dr. Ford: I do not feel that I am in a position to say very much about work of this character, which so manifestly has consumed many hours of energy, and such extended intellectual effort. Dr. Lewis's paper is a great surprise to me in some respects. I do not think that *a priori* any of us would have expected the tubercle bacillus to be more sensitive to disinfectants than are other [125] organisms. This calls to my mind the controversies which existed for some time after the bacillus was discovered. You may remember that the granular bodies that appear in the bacilli were first interpreted as spores. The proof that they are not spores rests upon their low thermal death point and upon the fact that the tubercle bacillus is not so resistant to disinfection as are organisms that produce spores. There are a number of phenomena suggesting that the tubercle bacillus is not destroyed at a temperature below 75 C. Other indications are that the thermal death point is 60 C., as for the ordinary non-sporulating bacteria. The matter was settled by Theobald Smith in experiments in which he showed that there had been certain fundamental errors in the observations of previous workers, and that if you took the tubercle bacillus and determined its thermal death-point with due regard to the fact that it is necessary to disinfect all parts of the tube, if you avoid all errors, the tubercle bacillus is found not to resist any greater degree of temperature than organisms like the typhoid or the color bacillus.

I do not think that anyone imagined that the tubercle bacillus was going to prove more sensitive to the action of drugs than are ordinary bacteria. In this connection Prof. Phelps of the Public

[125] Health Service demonstrated that, in ordinary disinfection, there are always some organisms that survive for long periods of time, and he regards disinfectants as acting according to chemical laws.

I do not recall whether Professor Phelps's work has even been confirmed or not. There are, however, some interesting things which have some relation to it and which tend to confirm it. If, for instance, you attempt to determine the action of heat upon milk and estimate the number of bacteria in milk and try to find the point at which all bacteria are destroyed, you find yourself beset with countless difficulties. You cannot easily find the point at which all bacteria are destroyed, and if you plot out your results, you get a curve like the one obtained by Professor Phelps with the disinfectants. In the same way Sedgwick and Winslow found that the destruction of bacteria in ice followed the same sort of curve. I do not know that this is any explanation of the points that Dr. Lewis has suggested, but it is analogous.

In connection with what Dr. Lewis said about the action of dyes immediately after heating, it is interesting to know that one sometimes gets similar reactions in saponin. If you heat your solution of saponin to determine the thermal death-point, you do not always find it, but the tubes which have been heated seem to be much more hæmolytic than the saponin was before it was heated.

Finally, it is very interesting to recall the influence of Ehrlich upon this work. After all, most of our studies in regard to disinfection followed along a certain level up to the time of Ehrlich's work, but since then we have had an entirely new series of observations which are extremely important.

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THE INFLUENCE OF CERTAIN ORGANIC SUBSTANCES ON THE GROWTH OF THE TUBERCLE BACILLUS.

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In attempting to treat experimental tuberculosis by well defined chemical compounds, it is important to know what relations exist between the tubercle bacillus and the chemicals, under various conditions of exposure. The present paper is intended as a contribution to our knowledge of these relations in as far as they can be studied in the culture flask.

HISTORICAL.

The general conception that it might be profitable to determine the power of substances to inhibit the growth of cultures, selecting the more active for subsequent therapeutic experimentation, was formulated by Robert Koch. The idea was completely developed by Bechhold and Ehrlich. The work of Koch and Bechhold and Ehrlich agreed in showing that substances might be highly active in the test-tube and still have no demonstrable capacity to sterilize the diseased animal. Ehrlich, moreover, showed conclusively in the course of his chemotherapeutic studies that substances without activity in the test-tube may be very active against the parasites in the body of the animal. In fact, until recently there was no instance known of a well defined chemical compound having pronounced disinfectant action in the test-tube and exerting the same in demonstrable degree in the animal body.

Schiemann[1] has recently developed the fact that salvarsan is active in the test-tube against anthrax bacilli, the bacillus of swine erysipelas, and *B. mallei* in dilutions of 1 : 1,000,000 or greater. Serum seems not to inhibit this action, but rather to favor it in certain instances. Against experimental infections with these microorganisms the drug also has a certain value. Ethylhydrocuprein (optochin), perhaps the one determinate chemical compound which has up to the present time been markedly effective *in vivo* against a bacterial infection (pneumococcus), has marked, and in some degree, at least, specific activities against the tubercle bacillus *in vitro*.

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[1] Schiemann, O., *Z. Immunitätsforsch., Orig.*, 1915–16, xxiv, 167.

Disinfectants as studied in the test-tube fall into two classes. One class is characterized by the possession of a more or less uniform action against all bacteria. If the action of phenol and mercuric chloride on a variety of bacterial species is compared, it is found that the mercurial compound is by far the more active agent (extraneous albumin being excluded from the reaction). The resistance of bacterial species also varies, some being susceptible, others relatively resistant. But if a ratio is drawn between the activity of phenol and bichloride of mercury for any single species of bacteria, that ratio will be approached closely by similar figures made up on the basis of experiment with any other race or strain of microorganism. Such substances are general disinfectants; they are more or less universal protoplasmic poisons, and, as a corollary to this, are apt to be proportionately far more toxic to higher animals than they are for microparasitic life.

The other, and from the point of view of experimental therapeutics, the more important class of disinfectants, is characterized by a limited range of action. Certain bacterial species only are affected in a marked degree by the typical members of the group. This is the ideal conception and one which is being more nearly fulfilled by the continued examination of substances from this point of view. In no instance, perhaps, up to the present time has the specificity displayed by the bacteriolysins of the blood serum of immune animals been uncovered as an attribute of well defined chemical compounds, although this result must be postulated as ultimately attainable.

The literature of this type of disinfectant action, designated by Ehrlich as *halb specifische*, or partially specific disinfection, is not extensive.

It was shown by Boer (1890)[2] in certain tables that malachite green and methyl violet act differently than a number of other disinfectant substances, showing a somewhat unusual degree of variation in their activity against certain bacteria. *B. anthracis* and *B. diphtheriæ* were about equally resistant to mineral acids, the stronger alkaline substances, salts of certain heavy metals, and phenol. *B. anthracis* was the more susceptible to malachite green in the proportion of 12 to 4, and to methyl violet in the ratio of 7 to 1. Boer did not comment on the possible significance of this observation.

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[2] Boer, O., in Behring's Gesammelte Abhandlungen, Leipsic, 1893, pt. i, 198.

Von Drigalski and Conradi (1902)[3] based a method for the differential isolation of *B. typhosus* on what they called the "elective bactericidal action" of certain aniline dyes—malachite green, brilliant green, methylene blue, methyl violet, and Krystallviolett were mentioned by them as showing this property. They recommended the addition to the culture medium of Kristallviolett in certain concentrations, especially to restrain the growth of cocci commonly found in the dejecta. Loeffler (1903)[4] found that a preparation of malachite green containing dextrin, when added to agar plates in concentrations of 1 : 1,000 to 1 : 4,000 restrained the growth of *B. coli* more than that of *B. typhosus*. He worked out and recommended a method for the rapid isolation of the typhoid bacillus on this basis.

Bechhold and Ehrlich[5] and subsequently Bechhold[6] developed most fully the partially specific nature of the disinfectant action of certain substances. The papers of these authors cannot be abstracted with advantage. Concerning our immediate problem, Bechhold reports some observations made with the tubercle bacillus, the substances tested having no demonstrable action against this species. Subsequently in a general review of this work, Bechhold[7] makes the statement that monochloronaphthol is highly active against the tubercle bacillus and *B. pyocyaneus*, but much less active against staphylococcus. He gives no exact figures nor does he state which of the several possible monochloronaphthols he employed.

DeWitt[8] in a study of the power of a number of aniline dyes to restrain the growth of various bacteria, records[9] the development of different bacterial species on agar to which the dyes had been added in the single concentration of about 1 : 8,000 (2 drops of a 1 per cent solution in 10 cc. of agar). Tests at a single concentration are not, of course, designed to bring out any specific quality which substances may possess. DeWitt's tables do, however, give some indication of this action. In most instances *B. subtilis* and *B. tuberculosis* were equally affected. With Bismarck brown, eosin A, erythrosin, and neutral red, the tubercle bacillus gave a feeble growth or none at all, while *B. subtilis* grew vigorously. With eosin (bluish) the reverse was found. In general, the growth of the tubercle bacillus was inhibited more readily than that of any other organism tested.

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[3] von Drigalski, and Conradi, H., *Z. Hyg. u. Infectionskrankh.*, 1902, xxxix, 283.

[4] Loeffler, *Deutsch. med. Woch.*, 1903, xxix, 286.

[5] Bechhold, H., and Ehrlich, P., *Z. physiol. Chem.*, 1906, xlvii, 173.

[6] Bechhold, H., *Z. Hyg. u. Infectionskrankh.*, 1909, lxiv, 113.

[7] Bechhold, Desinfektion, in Ehrlich's Festschrift, Jena, 1914, 505.

[8] DeWitt, L. M., *J. Infect. Dis.*, 1913, xii, 68.

[9] See Table V.

DeWitt's results are possibly less significant than they otherwise might be because the culture of the tubercle bacillus which she used was, as she states, of "questionable" authenticity. It was a rapidly growing culture producing abscesses in guinea pigs. She states that: "These abscesses are acute or at least develop much more rapidly than tuberculous glands, and other pigs in the same cage are infected." These characteristics are certainly not typical of the tubercle bacillus.

Our study as presented in this paper represents the beginning of a general survey of available organic chemicals with the view to determining which of them are able in some partially specific sense to restrain the growth of the tubercle bacillus. As will become apparent in the course of the paper, such an effort as this is subject to many limitations both as to method and material and the results can have at most a limited value. They are presented with the hope that they may form a useful guide to others interested in this field of work.

Method.

In general our method has been to make various dilutions in glycerol bouillon of the substances employed. The flasks containing these mixtures were inoculated with a surface growth of the tubercle bacillus, certain control flasks of the same bouillon being inoculated at the same time. When the growth on the control flasks completely covered the surface, the experiment was terminated by a comparison and record of the extent of growth throughout the series. The flasks were then inoculated with one drop of a 24 hour bouillon culture of *Bacillus typhosus* and a similar comparison was made on the following day of the degree of growth of this microorganism. Some comparisons were made with other bacteria to determine the general suitability of the typhoid bacillus as a standard. It would be impossible to cover a wide field of this nature without establishing some sort of routine procedure and we shall describe briefly the one that we have adopted after much preliminary experimentation.

Preparation of Solutions.—The preparation of the test fluids varies with the concentration desired. We use as the basis for our observations 20 cc. of glycerol bouillon (acidity 1.5 to 2 per cent phenolphthalein) in Jena glass boiling flasks of 50 cc. capacity. This gives a comparatively uniform surface area to be covered. For concentrations stronger than 1 : 1,000 the substance to be tested is weighed directly into the empty flask. We use a torsion balance for this work. The balance is simple and rapid in its operation and is adjusted to a sensitivity of 1 mg. Weighing 20 mg. and adding 20 cc. of bouillon gives a concentration of 1 : 1,000. The possible error at this concentration is 5 per cent, the probable error is less than this and would be equalized in a series of tests. The flasks are conveniently labeled by a ring of paper cut to hang over the neck.

When a series has been weighed off, the flasks plugged with cotton are sterilized with dry heat. Most of the substances we have studied so far stand a temperature of 130°C. without decomposition when dry. This temperature continued for 3 hours will usually render the preparation sterile. The bouillon measured into similar flasks is separately sterilized in the autoclave. When ready it is poured into the flask with the weighed, sterilized substance. This can be accomplished with only small losses due to contamination. For lesser concentrations, 1 : 1,000 to 1 : 10,000, the 1 : 1,000 solution in bouillon is diluted with glycerol bouillon with suitable pipettes.

For concentration below 1: 10,000 we start with 25 mg. of the substance sterilized by dry heat in a suitable flask and then add sterile water to make a 1 : 1,000 solution. This is then measured into the bouillon flasks; 2 cc. for 1 : 10,000, 1 cc. for 1 : 20,000, etc.

According to the method of preparation, it will be noted that the concentrations given in the tables are only approximately correct. The actual concentrations, 1 : 11,000, 1 : 21,000, 1 : 40,500, etc., can be substituted, but the round numbers are more convenient to handle and are close enough for our present purpose.

Many substances can be more simply handled by sterilizing the finished solution in bouillon. So large a number are either decomposed or enter into fixed combinations with bouillon constituents when treated in this way that we recommend the above procedure as a rule. Certain substances which can be sterilized successfully in watery solution decompose at the temperature mentioned when dry. They are relatively few and must be handled by other procedures.

Cultures Used.—As the culture for all this work we have used a strain of *Bacillus tuberculosis* obtained some years ago from The

Rockefeller Institute for Medical Research designated Bovine III. This culture is probably a transplant of the Bovine III of Theobald Smith. A comparison with the latter strain, however, shows that our culture grows rather more vigorously and is definitely less virulent for guinea pigs. Our culture does, however, give the characteristic disease in guinea pigs and rabbits, is acid-fast, and produces no acid in glycerol bouillon. It is evidently a culture of bovine type of low virulence. The results obtained with this culture have been checked in certain instances with other cultures of higher virulence, also vigorous growers, and found to be identical. We have so far made no comparison with recently isolated cultures, which offer an important problem, but a distinct one.

The stock culture for this work is kept on glycerol bouillon. Cultures about 3 weeks old have usually been used for the inoculation. The inoculation is made with a fine straight wire, a bit of the growth 1 or 2 mm. in diameter being carried over. For each separate lot of culture medium used, at least five control flasks have been inoculated in series with those test substances in which that particular bouillon was concerned. This is essential.

The culture Bovine III can be depended on to give a growth over all of the surface of flasks as we have used them in from 1 to 2 weeks. When the surface of all the control flasks is just overgrown we have terminated the observation period.

For the tests with *Bacillus typhosus* we have used the Rawlings strain obtained some time ago through the courtesy of Major Russell, of the United States Army.

Recording Results.—The results are recorded by an inspection of the flasks. The original bit of culture at least must remain visible if the experiment is to be considered conclusive. If it is shaken down by accident or sinks spontaneously, growth cannot occur from the bottom. The designations used are as follows:

No growth indicates that the original bit is thin and dry; very slight, that the original bit is thickened but shows no new surrounding film; slight, that there is a definite film of new growth extending from the original, the whole mass being 1 cm. or less in diameter; moderate, that the surface is about one-fourth covered; good, that the surface is one-fourth to three-fourths covered; and full, that the surface is completely covered or nearly so.

Occasional lots of bouillon are encountered in which after a period of growth there is a cessation with the surface of the control flasks about three-fourths covered. Tests in which this occurs must be discarded.

The results of the tests with *Bacillus typhosus* are recorded in the same terms based on the examination of a hanging drop taken from the flasks at the end of a 24 hour period of growth. The slight and moderate grade degrees of proliferation are frequently marked by phenomena of agglutination and involution which help to fix the amount of inhibition which prevails. A numerical expression could be obtained by plating, but it is doubtful if this would be of use for the present purpose in view of the fact that no such system could be applied to the tubercle bacillus.

Materials Used.—The substances reported in this paper are nearly all aniline dyes. They have been obtained partly by purchase in the market and partly by donation.[10] These commercial dyes contain a varying proportion of impurities, especially inorganic salts. They should in many instances undoubtedly be considered as mixtures of more or less closely related substances rather than as chemical entities. The salts should be considered as diluents. In the concentrations we are considering they probably have no effect on growth. In so far as it is possible that other impurities may exist in any preparation and increase its activity, the results now reported cannot be considered as final. On the whole, this is probably not a factor in many instances. To exclude it as a possibility in any case involves so much careful work that it can only be attempted on a selected material and as a special problem. We have already approached this matter in certain cases which seemed to be especially significant in their bearing on the influence of chemical constitution on the result. Such observations as we have made will be reserved for later publication.

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[10] We are indebted to the American agents of Kalle and Company, and the Bayer Company, for sample lines of the azo-dyes put in the trade by their respective firms. We are also indebted to Professor W. T. Taggart of the University of Pennsylvania for large contributions from a collection of dyes maintained by the Department of Organic Chemistry. The dyes purchased have been obtained chiefly from Grübler and Kahlbaum.

RESULTS.

The results of this survey as carried out up to the present time are given in Tables I to VI. The tables show the name of the preparation tested and its source. They show the greatest concentration at which growth is full for each culture of *Bacillus tuberculosis* and *Bacillus typhosus*. These concentrations are combined in a factor which is an expression of the relative susceptibility to the inhibiting action of the dye. The point of full growth was taken as the basis of this comparison because it permits of the consideration of a much larger number of substances than does the point of complete inhibition. The point of no growth for the typhoid bacillus can be determined in comparatively few instances. In certain cases it has been possible to compare the influence of substance for all concentrations from no growth to full growth with each bacterial species. In these cases the factor has been much the same with whichever concentration was made the basis for comparison.

The substances have been arranged in the tables in groups according to their activity against the tubercle bacillus. With the substances showing much activity it is usually possible to show a restraining action on the typhoid bacillus at some concentration. For less active substances the typhoid organism frequently grows without restraint in a saturated solution. In these cases it is only possible to indicate that the factor is greater than the value actually determinable.

The interest of the laboratory has centered for some time on the action of certain azo-dyes which are vital stains. For this reason the number of this class of dyes examined is large, and out of proportion to those of other constitution. These are tabulated by themselves in the case of the more active ones. In making this separation we have relied in most instances on the tables of Schultz.[11]

Interpretation of Results.—There is perhaps little that can be said at this time in extension of the actual results of the work presented. It is evident that a great variety of substances have marked capacity to restrain the growth of the tubercle bacillus. Those dyes whose disinfectant activities have long been known to be considerable,

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[11] Schultz, G., Farbstofftabellen, Berlin, 5th edition, 1914.

TABLE I.

Dyes of Various Groups Strongly Restraining Growth of the Tubercle Bacillus.

Designation.	Source.	Tubercle bacillus growth full at.	Typhoid bacillus growth full at.	$\frac{\text{Typhoid bacillus}}{\text{Tubercle bacillus}}$
Acridinorange............	G.*	1 : 1,000,000	1 : 4,000	$\frac{250}{1}$
Äthylrot..................	Kahl.	1 : 200,000	1 : 1,000 (Saturated.)	$\frac{200}{1}+$
Auramin..................	G.	1 : 200,000	1 : 4,000	$\frac{50}{1}$
" O................	Kahl.	1 : 200,000	1 : 4,000	$\frac{50}{1}$
Aurantia (Kryst.)..........	G.	1 : 4,000,000	1 : 1,000 (Saturated.)	$\frac{4000}{1}+$
Azur II..................	"	1 : 200,000	1 : 2,000	$\frac{100}{1}$
Chinolinrot................	Kahl.	1 : 400,000	1 : 40,000	$\frac{10}{1}$
Chrysanilin................	"	1 : 200,000	1 : 4,000	$\frac{50}{1}$
Coerulein S................	G.	1 : 100,000	1 : 1,000 (Saturated.)	$\frac{100}{1}+$
Cresylechtviolett..........	"	1 : 400,000	1 : 2,000	$\frac{200}{1}$
Krystallviolett............	"	1 : 1,000,000	1 : 100,000	$\frac{10}{1}$
" (Hoechst)....	"	1 : 200,000	1 : 100,000	$\frac{2}{1}$
Dahlia....................	"	1 : 100,000	1 : 10,000	$\frac{10}{1}$
Diamantfuchsin............	"	1 : 100,000	1 : 4,000	$\frac{25}{1}$
Heliotrop..................	Kalle.	1 : 4,000,000	1 : 8,000	$\frac{500}{1}$
Indaminblau N extra.....	Kahl.	1 : 200,000	1 : 2,000	$\frac{100}{1}$
Janusgrün................	G.	1 : 400,000	1 : 8,000	$\frac{50}{1}$
Magentarot................	"	1 : 200,000	1 : 5,000	$\frac{40}{1}$
Mauvien..................	"	1 : 400,000	1 : 1,000 (Saturated.)	$\frac{400}{1}+$
Methylene blue...........	Merck.	1 : 1,000,000	1 : 2,000	$\frac{500}{1}$

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* In the tables, G. indicates Grübler; Kahl., Kahlbaum; Kalle, Kalle and Company; By., Bayer and Company. The other names are self-explanatory.

TABLE I—*Concluded.*

Designation.	Source.	Tubercle bacillus growth full at.	Typhoid bacillus growth full at.	$\frac{\text{Typhoid bacillus}}{\text{Tubercle bacillus}}$
Methylengrün	G.	1 : 200,000	1 : 2,000	$\frac{100}{1}$
Methylenviolett	“	1 : 2,000,000	1 : 4,000	$\frac{500}{1}$
Methylviolett (Kryst.)	Kahl.	1 : 200,000	1 : 100,000	$\frac{2}{1}$
“ B	G.	1 : 200,000	1 : 20,000	$\frac{10}{1}$
“ 5B	“	1 : 200,000	1 : 40,000	$\frac{5}{1}$
“ 6B extra	Kahl.	1 : 400,000	1 : 40,000	$\frac{10}{1}$
Neutral blue W	Kalle.	1 : 200,000	1 : 1,000 (Saturated.)	$\frac{200}{1}+$
“ red	G.	1 : 400,000	1 : 100 (Incomplete.)	$\frac{4000}{1}+$
Nilblau (sulfat)	“	1 : 2,000,000	1 : 4,000	$\frac{500}{1}$
Orcein	“	1 : 100,000	1 : 800	$\frac{125}{1}$
Orcin	“	1 : 100,000	1 : 2,000	$\frac{50}{1}$
Phosphin I	Unknown.	1 : 400,000	1 : 2,000 (Saturated.)	$\frac{200}{1}+$
“ 3R	Kahl.	1 : 400,000	1 : 8,000	$\frac{50}{1}$
Resorcin fuchsin	G.	1 : 100,000	1 : 2,000	$\frac{50}{1}$
Rosanilin-acetat	Kahl.	1 : 200,000	1 : 4,000	$\frac{50}{1}$
Safranin 3B	Kalle.	1 : 2,000,000	1 : 4,000	$\frac{500}{1}$
“ base	Unknown.	1 : 1,000,000	1 : 8,000	$\frac{125}{1}$
“ MN	Badische.	1 : 2,000,000	1 : 4,000	$\frac{500}{1}$
“ rein	G.	1 : 400,000	1 : 8,000	$\frac{50}{1}$
Spiller's purple	“	1 : 200,000	1 : 200,000	$\frac{1}{1}$

TABLE II.

Azo-Dyes Strongly Restraining Growth of the Tubercle Bacillus.

Designation.	Source.	Tubercle bacillus growth full at.	Typhoid bacillus growth full at.	$\frac{\text{Typhoid bacillus}}{\text{Tubercle bacillus}}$
Alkaligrün	G.	1 : 200,000	1 : 200 (Saturated.)	$\frac{1000}{1}+$
Anilingelb	"	1 : 100,000	1 : 4,000	$\frac{25}{1}$
Benzobraun G	By.	1 : 200,000	1 : 200 (Saturated.)	$\frac{1000}{1}+$
Biebricher Scharlach	G.	1 : 200,000	1 : 100 "	$\frac{2000}{1}+$
Chromanilbraun R	Kahl.	1 : 100,000	1 : 100 "	$\frac{1000}{1}+$
Chrysamin	G.	1 : 100,000	1 : 1,000 "	$\frac{100}{1}+$
Chrysoidin	"	1 : 100,000	1 : 2,000	$\frac{50}{1}$
" extra	Kahl.	1 : 100,000	1 : 2,000	$\frac{50}{1}$
Cloth red 3B extra	By.	1 : 200,000	1 : 1,000 (Saturated.)	$\frac{200}{1}+$
" " 3G "	"	1 : 200,000	1 : 1,000 "	$\frac{200}{1}+$
Dicyanin	Kahl.	1 : 100,000	1 : 1,000 "	$\frac{100}{1}+$
Doppelponceau 4R	By.	1 : 100,000	1 : 4,000 "	$\frac{25}{1}+$
Goldorange	G.	1 : 200,000	1 : 1,000 "	$\frac{200}{1}+$
Havannabraun I	Kahl.	1 : 100,000	1 : 1,000 "	$\frac{100}{1}+$
Helianthin	G.	1 : 200,000	1 : 1,000 "	$\frac{200}{1}+$
Indian yellow G	By.	1 : 100,000	1 : 1,000 "	$\frac{100}{1}+$
Mandarin G extra	Kahl.	1 : 200,000	1 : 200 "	$\frac{1000}{1}+$
Metanilgelb 1a	G.	1 : 400,000	1 : 1,000 "	$\frac{400}{1}+$
" extra	Kahl.	1 : 400,000	1 : 1,000 "	$\frac{400}{1}+$

TABLE II—*Concluded.*

Designation.	Source.	Tubercle bacillus growth full at.	Typhoid bacillus growth full at.	Tubercle bacillus / Typhoid bacillus
Methylorange	G.	1 : 200,000	1 : 1,000 (Saturated.)	$\frac{200}{1}+$
Naphtaminbraun 2B	Kalle.	1 : 200,000	1 : 200 "	$\frac{1000}{1}+$
" GX	"	1 : 100,000	1 : 1,000 "	$\frac{100}{1}+$
Naphtamin fast black SDE	"	1 : 100,000	1 : 1,000 "	$\frac{100}{1}+$
Naphtamingrün A	"	1 : 100,000	1 : 1,000 "	$\frac{100}{1}+$
" AG	"	1 : 100,000	1 : 1,000 "	$\frac{100}{1}+$
" B	"	1 : 100,000	1 : 1,000 "	$\frac{100}{1}+$
Naphtaminviolett N	"	1 : 100,000	1 : 1,000 "	$\frac{100}{1}+$
Naphthylamine black NR	"	1 : 100,000	1 : 200 "	$\frac{500}{1}+$
Orange IV	Kahl.	1 : 1,000,000	1 : 1,000 "	$\frac{1000}{1}+$
Pyraminorange RT	Badische.	1 : 100,000	1 : 100 (Incomplete.)	$\frac{1000}{1}+$
Säurebraun	G.	1 : 100,000	1 : 100 (Saturated.)	$\frac{1000}{1}+$
Tropaeolin OO	"	1 : 100,000	1 : 1,000 "	$\frac{100}{1}+$
Wollschwarz	"	1 : 400,000	1 : 400	$\frac{1000}{1}$

the methyl violets for example, are no more active than many others whose general action is limited, as represented by the *Bacillus typhosus* results. The power to inhibit the growth of the tubercle bacillus is limited to no general class of coal-tar dye. It is noteworthy that a great many azo-dyes possess this characteristic although few of them are active against *Bacillus typhosus* in a marked degree.

A general view of the results suggests that in the tubercle bacillus we have a bacterium which is highly sensitive to slight modifica-

TABLE III.

Dyes of Various Groups Restraining Growth of the Tubercle Bacillus Moderately.

Designation.	Source.	Tubercle bacillus growth full at.	Typhoid bacillus growth full at.	Tubercle bacillus / Typhoid bacillus
Anthracenblau	G.	1 : 40,000	1 : 1,000 (Saturated.)	$\frac{40}{1}+$
Brillantkresylblau	"	1 : 40,000	1 : 1,000	$\frac{40}{1}$
Curcumein N.	"	1 : 40,000	1 : 1,000 (Saturated.)	$\frac{40}{1}+$
Echtrot	"	1 : 20,000	1 : 1,000 "	$\frac{20}{1}+$
Indulin	"	1 : 20,000	1 : 1,000 "	$\frac{20}{1}+$
Isaminblau 8B	Cassella Color Co.	1 : 20,000	1 : 100 "	$\frac{200}{1}+$
Kresofuchsin	G.	1 : 20,000	1 : 1,000 "	$\frac{20}{1}+$
Malachitgrün Ia	"	1 : 20,000	1 : 4,000	$\frac{5}{1}$
Muscarin	"	1 : 40,000	1 : 1,000 (Saturated.)	$\frac{40}{1}+$
Nachtblau	"	1 : 20,000	1 : 1,000 "	$\frac{20}{1}+$
Naphtalinrot	"	1 : 20,000	1 : 1,000 "	$\frac{20}{1}+$
Pararosanilin chlorhydrat	Kahl.	1 : 40,000	1 : 2,000	$\frac{20}{1}$
Pyronin	G.	1 : 20,000	1 : 4,000	$\frac{5}{1}$
Rhodamin B	Kahl.	1 : 20,000	1 : 100 (Incomplete.)	$\frac{200}{1}+$
Victoriablau B	"	1 : 20,000	1 : 10,000	$\frac{2}{1}$
" 4R	G.	1 : 20,000	1 : 10,000	$\frac{2}{1}$

TABLE IV.

Azo-Dyes Restraining Growth of the Tubercle Bacillus Moderately.

Designation.	Source.	Tubercle bacillus growth full at.	Typhoid bacillus growth full at.	$\frac{\text{Tubercle bacillus}}{\text{Typhoid bacillus}}$
Bordeaux BX............	By.	1 : 20,000	1 : 100 (Saturated.)	$\frac{200}{1}+$
Chrysamin G..............	"	1 : 20,000	1 : 1,000 "	$\frac{20}{1}+$
Diamantschwarz PV........	"	1 : 20,000	1 : 200 "	$\frac{100}{1}+$
Doppelponceau 2R.........	"	1 : 20,000	1 : 1,000 "	$\frac{20}{1}+$
Naphtaminschwarz 2RE....	Kalle.	1 : 20,000	1 : 100 "	$\frac{200}{1}+$
" 3RE....	"	1 : 20,000	1 : 2,000	$\frac{10}{1}$
Naphtaminblau 12B........	"	1 : 20,000	1 : 100 (Saturated.)	$\frac{200}{1}+$
" BE.........	"	1 : 20,000	1 : 100 "	$\frac{200}{1}+$
" BXG.......	"	1 : 20,000	1 : 100 "	$\frac{200}{1}+$
" BXR.......	"	1 : 20,000	1 : 100 "	$\frac{200}{1}+$
Naphtaminbraun H.........	"	1 : 20,000	1 : 1,000 "	$\frac{20}{1}+$
" RB.......	"	1 : 40,000	1 : 400 "	$\frac{100}{1}+$
Naphtamindirektschwarz C.	"	1 : 20,000	1 : 1,000 "	$\frac{20}{1}+$
Naphtamindirektschwarz RWK..................	"	1 : 20,000	1 : 400 "	$\frac{50}{1}+$
Naphtaminechtscharlach B..	"	1 : 40,000	1 : 1,000 "	$\frac{40}{1}+$
" R.	"	1 : 40,000	1 : 1,000 "	$\frac{40}{1}+$
Naphtaminorange 2R......	"	1 : 40,000	1 : 1,000 "	$\frac{40}{1}+$
Naphtaminrot H...........	"	1 : 40,000	1 : 1,000 "	$\frac{40}{1}+$
Naphtylamingelb..........	G.	1 : 40,000	1 : 4,000	$\frac{10}{1}$

TABLE IV—*Concluded.*

Designation.	Source.	Tubercle bacillus growth full at.	Typhoid bacillus growth full at.	$\frac{\text{Tubercle bacillus}}{\text{Typhoid bacillus}}$
Neucoccin.................	Kahl.	1 : 20,000	1 : 100 (Incomplete.)	$\frac{200}{1}+$
Purpurin sicc. opt..........	G.	1 : 20,000	1 : 1,000 (Saturated.)	$\frac{20}{1}+$
Roseazurin G.	By.	1 : 20,000	1 : 4,000 "	$\frac{5}{1}+$
Sulfonazurin D............	"	1 : 20,000	1 : 1,000 "	$\frac{20}{1}+$
Sulfoncyanin G............	"	1 : 40,000	1 : 1,000 "	$\frac{40}{1}+$
Wollschwarz 4B............	Kahl.	1 : 20,000	1 : 200 "	$\frac{100}{1}+$

tions of growth conditions and that we are dealing with a reaction here which bears no real relation to the more usual forms of disinfectant action. This may be the case, but the explanation is hardly constructive. We hope to have for presentation in the near future a series of tests with the pneumococcus carried out on similar lines. It is apparent from what we have done with the pneumococcus that sensitiveness to reaction and exact constitution of the culture medium does not imply sensitiveness to the inhibiting action of dyes as we have developed it in the case of the tubercle bacillus.

Many of these dyes, in fact by far the larger number, stain the growing membrane with greater or less intensity. The individual bacilli in the membrane are much less frequently stained and then only by concentrations much greater than those required to inhibit growth. The restraint of growth seems in no way related to the staining of the membrane.

The staining of the membrane may in some instances possibly render the figures inaccurate. In the case of dyes exhibiting great activity, such as heliotrope, methylene blue, and others, the membrane absorbs the dye from weak solutions so that the concentration in the immediate vicinity of the bacilli is much higher than the dilution number would imply. Whether this increased concentration

TABLE V.

*Weaker Dyes in Concentrations of 1 : 1,000 to 1 : 10,000 Showing Full Growth of the Tubercle Bacillus.**

Designation.	Source.	Designation.	Source.
Acridinrot	G.	Naphtamindirektschwarz EK	Kalle.
Alizarin red	Eimer and Amend.	Naphtamindirektschwarz O.	"
Alizarincyanin	Kahl.	Naphtamindirektbraun 2R	"
Alkaliblau 3B	"	" GR	"
Anilinblau	G.	" V	"
Aniline blue black	"	Naphtamine fast black KS	"
Azosäureblau 2G	By.	Naphtamingrün AB	"
Azoblau	G.	" TE	"
Bayerischblau	Kahl.	Naphtaminorange FB	"
Benzoolive	By.	Naphtaminscharlach B	"
Blauschwarz	G.	Naphtaminviolett BE	"
Bordeaux G.	By.	Naphtholgelb S	G.
Brillantcrocein 3BA	"	Naphtholgrün B	"
Chromgelb D	"	Naphtholorange	Kahl.
Congo-corinth	G.	Naphtholschwarz B	"
Congo red	Unknown.	Naphthylaminschwarz BN	Kalle.
Congorubin	Kalle.	" BNN	"
Echtgrün	G.	" BOO	"
Heliotrop B	Kalle.	" NA	"
Isaminblau 6B	Cassella Color Co.	Nigrosin	G.
" R	Cassella Color Co.	Patentblau A	Kahl.
Jodgrün	G.	Phloxinrot	G.
Lichtgrün	"	Ponceau PR	"
Magdalarot echt	"	" (Kryst.) 6 RF	Kahl.
Methylgrün rein OO	"	Resedagrün	"
Naphtaminschwarz GE	Kalle.	Rosazurin B	G.
" H	"	Rose bengale	"
" HRE	"	Säuregrün	"
" 4RE	"	Säureviolett 6B	Kahl.
Naphtaminblau 2BK	"	" (Kühne)	G.
" 3RE	"	Sulfonsäureblau R	By.
Naphtaminbrillantblau BW	"	Sulforhodamin	Metz and Co.
" G	"	Thiazinbraun	G.
Naphtaminbraun 8B	"	Tropaeolin	Kahl.
" 4G extra	"	Trypanrot	G.
		Victoriascharlach 4R	Kahl.
		Violettschwarz	G.

* The $\frac{\text{tubercle bacillus}}{\text{typhoid bacillus}}$ factor is indeterminable, except in a few instances, because of the inactivity of the dyes against the typhoid bacillus.

TABLE VI.

Very Inactive. Full Growth at 1 : 1,000 or Stronger.

Designation.	Source.	Designation.	Source.
Äthylgrün (Kryst.)	Kahl.	Fast brown 26048	By.
Aniline red	Merck.	" yellow extra	"
Azocarmin	G.	Flavazin G	Kahl.
Azoeosin	By.	Fluorescein	G.
Azogrenadin L.	"	Fuchsin S.	"
Azolitmin	A. H. Thomas and Co.	Gallein (sicc.)	"
		Gentianablau 6B	Kahl.
Azorubin S.	Kahl.	Isaminblau B	Cassella Color Co
Baumwollblau	"		
Benzoazurin	G.	Methyleosin	G.
" G	Kalle.	Naphtaminschwarz RGE	Kalle.
Benzopurpurin	G.	Naphtaminblau 7B	"
Benzo sky blue	By.	" 2BL	"
Bittermandelölgrün	G.	" JE	"
Bleu de Lyon	"	Naphtaminbrillantblau B	"
Bordeaux R	Kahl.	" BWO	"
Brillantazurin 5G	By.	Naphtamintiefschwarz HW.	"
Brillantgrün	Kahl.	Naphtaminechtschwarz SE.	"
"	G.	" TE	"
Brillantschwarz	"	Naphthylaminschwarz 10B	By.
Carminic acid Ia	"	Orange G	G.
Chinablau	"	Oxaminviolett	Badische
Chinagrün	"	Patentsäure rubin	G.
Chinolingelb (wasserlöslich)	Kahl.	Ponceau 3R	Kahl.
Chinolingelb	Uncertain.	" 4R	"
"	Badische.	Rapid filter gelb	"
Chloraminorange G	By.	" " grün I	"
Chromotrop	G.	" " rot I	"
" 2R	Kahl.	Rosazurin G	G.
Crocein	G.	Rubin S.	"
Diaminblau 3B	Kahl.	Säurecyanin G	Kahl.
" B	"	Säureschwarz B	"
Direktblauschwarz 2B	By.	Säureviolett 1897	G.
Direktgelb R	"	Tartrazin	By.
Echtrot D	Kahl.	Thiazinrot	G.
Eosin (bläulich)	"	Thiazolgelb	Kahl.
" (clairl.)	G.	Victoria violet 4BS extra	By.
" (gelblich)	Kahl.	Wasserblau	G.
" (rein franz.)	G.	" 3B	Kahl.
Erythrosin	"	" 6B	"

is effectively applied against the growth of the microorganism cannot be determined.

The figures presented above, studied in conjunction with what is known of the chemical constitution of the dyes, are suggestive. The quality of the material does not permit accurate judgment and as we expect to have ready shortly similar observations made with especially prepared or purified substances much more suited for these considerations, this discussion will be deferred for the present.

An important question raised by these observations is the relation between the capacity to restrain growth as shown above, and true disinfectant action or killing power of the substances in question. It has been repeatedly shown that in the case of true disinfectants their capacity to restrain growth is roughly proportional to their killing power. In the tables it appears that the dyes which have long been recognized to have disinfectant action, certain of the triphenyl methanes particularly, belong to the group of substances with a high power to restrain the growth of the tubercle bacillus. In all previous consideration of this question, the starting point has been the substance whose lethal action was known. That there might be substances having marked capacity to restrain growth with no corresponding capacity to kill does not seem to have occurred to previous investigators in this field.[12] Contrasting the great inhibitory power of methylene blue in our hands and the low killing power of this dye in the work of DeWitt with the previous observations on this relation, we may safely conclude that there is no close or constant correlation between the two forms of action. Special work directed towards this point is required before a precise conclusion can be reached.

SUMMARY.

The power of a large number of aniline dyes to restrain the growth of *Bacillus tuberculosis* and *Bacillus typhosus* has been determined. Many substances have been found with especial restraining power

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[12] Gotschlich, E., in Kolle, W., and von Wassermann, A., Handbuch der pathogenen Mikroorganismen, Jena, 2nd edition, 1913, iii, 479, states that formaldehyde has, as contrasted with other disinfectants of similar lethal value, a high capacity to inhibit growth.

for the tubercle bacillus under the conditions of the test. This capacity to restrain growth in the case of the tubercle bacillus apparently bears no simple relation to true disinfectant action. Opinion as to whether the active substances exert a truly specific activity against the tubercle bacillus or whether the activity is determined by the peculiar conditions imposed by the growth of this bacterium as a surface membrane are left for future consideration.

UNIVERSITY OF PENNSYLVANIA

FOURTEENTH REPORT

OF THE

HENRY PHIPPS INSTITUTE

FOR THE STUDY, TREATMENT, AND PREVENTION OF TUBERCULOSIS

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* Since about May 1, 1918, the Laboratory has been used by the Government as a central laboratory for the Fourth Naval District, and as an adjunct to the U. S. Naval Medical School, Washington.

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DIETARY HABITS AND THEIR IMPROVEMENT

SOME RESULTS OF THE WORK OF PHIPPS INSTITUTE

By H. R. M. Landis, M.D.,

Director of Clinical and Sociological Departments, Phipps Institute.

Anybody who has worked among the laboring classes and has any knowledge of the small wage-earner, realizes very quickly that there is no other class of people who are so shockingly extravagant and so ignorant in the making of their purchases, not only as to food but in other directions, and this holds true and did hold true long before food shortage became such a vital question; it has always been a vital question with them.

In one study that we made at Phipps Institute, some years ago, on the relationship that might possibly exist between tuberculosis and the garment-making trade, we found that in those individuals who were getting insufficient food or who were taking their food at irregular intervals the incidence of tuberculosis was higher than among those adequately fed. Among the men there was a very considerable proportion of those with a food deficiency who developed not only tuberculosis but other ailments; among the women, the proportion was almost three times as great as with those who were getting an adequate diet.[1] I have no hesitation in saying that malnutrition is probably one of the most potent causes of tuberculosis that we have among the working class. It leads to a lowered resistance and is to be ascribed in some instances to poverty, but quite as often it is due to ignorance on their part as to the food they should get.

Another study we made, of an intensive nature, was that of studying very completely, twelve families, these twelve families being represented by three Italian families, three Russian Jewish families, three negro families and three Polish families. This study was conducted for a period of two weeks, and in each of the families a very accurate estimation was made. A nurse went to each one of the homes and weighed all the food they had on hand when the study started, weighed all the food purchased each day and what was left at the end of the study was subtracted from the total. The amount used was then reduced to calories.

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[1] Eighth Report, Phipps Institute, 1915.

This study brought out some very interesting facts as to racial characteristics, not only as to the type of food but more particularly as to racial economy in food purchases.

The Italians made by far the best showing. Reducing each one of these families to men per day, we found that the Italian families were feeding themselves at the rate of nineteen cents per man per day. The negroes came next with twenty-two cents; the Russian Jews, twenty-four cents, and the Poles jumped up to thirty-four cents, and in one Polish family they were spending forty-two cents per man per day.[2]

As to the composition of the food, the Italians were getting almost 75 per cent of carbohydrates and were getting less than one-half of the amount of protein that is ordinarily believed to be necessary. In talking with Dr. A. E. Taylor about this, he offered the explanation that the Latin races, as a whole, are the only ones who have adequately solved the problem of preparing carbohydrate foods and have been able to cook them in a palatable form so that they are readily eaten and can be subsisted on without any great detriment.

The negro, for some reason, as I found not only in our own experiment but in other investigations, runs to a very high fat content in his diet. He not only eats large quantities of fat, but the other articles of his diet are commonly cooked in fat. The Russian Jews subsisted on a diet which was more nearly balanced than that of any of the others. The Polish families were getting a diet that was pretty fairly balanced, but in going over it and analyzing the diets per family, it was found that they were buying a large amount of food stuff in which there was no essential food value at all. In other words, they were extremely lavish in their expenditures and did not begin to get out of their purchases what they should in the way of absolute food value.

The result of this study was that it seemed apparent to us that the dispensary patient seems to be getting about four-fifths of the amount of food that he should. In other words there is just that subnormal amount all the time that is probably lowering his resistance and if there is any additional strain put upon him he readily falls the victim of some disease.[3]

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[2] The figures quoted are those of two and a half years ago.

The influence of good food has nowhere been better demonstrated than in our open-air schools. In the beginning children referred to the open-air schools were designated as tuberculous or pretuberculous. More often, however, they are delicate, undernourished children, who are without any apparent organic disease that you can put your hands on, the chief difficulty seeming to be that of malnutrition. When they are placed in an open-air school and supplied at the same time with at least one mixed meal, these children make the most amazing gains in weight.

A study somewhat similar to that made by us was conducted by Miss Lucy Gillette for the New York Association for Improving Conditions among the Poor. An intensive study was made of children. She found that there were certain variations as to the food requirements for different types of individuals. She points out very clearly that the delicate child, one that is emaciated and under-nourished, is one that inevitably needs a vastly larger food supply than the child under ordinary conditions.

I was much interested only a short time ago, as pointing to the ignorance of food values which I think obtains among the masses pretty generally, in a statement made by the Chief of the Department of Food Hygiene of the Argentine Republic, to the effect that, among the laborers in Argentina, as a whole, a most inadequate knowledge of and the most thriftless habits in regard to food prevailed. In his opinion there was most urgent need for legislation which would see to it that these people got a better balanced diet. Legislation, I believe, would not have the slightest influence. I think the problem is one entirely of education. This brings up the question of how to teach people the kind of and the amount of food that they should get each day. Personally, my experience has been that irrespective of the race, there is a tendency to take a diet that is more or less similar. One race may eat a little more fat and another go a little further in carbohydrates, but there is this tendency to use a mixed diet, and where they have their independent choice, they keep away from any set food formula.

But the essential thing is to teach people the quantity and quality of food desirable and in addition the relative values of different foods. Our experience at the Phipps Institute has been that housewives vary tremendously in their purchasing abilities; one woman, for instance, for every ten cents, would get food equivalent to fifteen hundred calories, another would get only nine hundred. In other words, there was a difference of almost 40 per cent between the purchasing power of two women.

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[3] Craig and Landis; Transactions Association American Physicians, 1916.

In some of the work that we have done in connection with tuberculosis classes, we watched more or less closely the amount of food the patients were getting. It was necessary, in almost every instance, to show them the kinds and amounts of food needed. If there were available four or five dollars a week for food in a family of five—I am quoting figures for six years ago—it became necessary in nearly every instance to show them exactly how they should spend those four or five dollars to get the food that would give them the best returns.

The only way we have of controlling the amount of food we are giving to an individual and determining whether that individual is on a subnormal diet or not, is by the caloric method. I want it understood, of course, that the calory does not mean everything. We have to take into consideration the preparation of the food and very often, the service of the food and, in addition, to keep in mind, the use of those foodstuffs which furnish the so-called vitamines. But the caloric method is necessary as a means of determining whether the individual is on a subnormal diet, or whether, perhaps, he is being overfed, as many are. In one school which was investigated, it was found that the boys were each receiving about 5,500 calories daily and in addition were getting about 500 more outside in the form of candy. In other words, they were tremendously overfed.

The difficulty with the caloric method has been that lay people as a whole have very little conception of what is meant by a calory; and it is undoubtedly true that many physicians have a very hazy idea of what is meant if you say that an individual should have 2,200 or 3,000 calories a day. The great trouble with the caloric method has been the difficulty of translating the values in intelligible form to the individual who knows nothing about them. One of the difficulties has been that it is a tremendous tax on the memory to recall that so many grams of a certain amount of food equal 135 calories, and so many grams of another kind of food equal 40 calories.

What I believe to have been a marked advance in the introduction of the caloric method was a suggestion first made by Dr. Irving Fisher, by which you use a common unit of 100. The next advance in this line was made by Dr. William Emerson, of Boston, who translated these 100 calories into perfectly familiar terms so that even the most ignorant housewife could understand. He has reduced them, for instance, to teaspoonfuls, cupfuls and so on—a teaspoonful of a given amount of food equals a hundred calories, so in that way the values could be very easily followed. He has had an exhibit prepared on these lines which he has used with extraordinarily good effect in the teaching of dietetics to delicate children. In this way he has been able to teach children, of even seven or eight years of age, how many calories they have taken a day and how many more they need to make up their quota. It is not so difficult to teach even the individual with a very slight amount of education what you mean when you say that he must have 2,200 or 2,400 calories of food per day when this is translated into familiar measurements. I have had one of these food exhibits made because it visualizes these values and enables one to learn more in a few minutes than any amount of talking would do concerning caloric feeding.

For instance, it does not take very long to remember that approximately a quart of bouillon made of the very best meat you can get is 100 calories, and you can contrast that with two tablespoonfuls of lima beans, which have a food value of 100 calories. The banana, equaling 100 calories, is one of the easiest articles of diet to get, is always on the market, and has recently been shown to be practically the equivalent of the potato. It can be eaten as almost the sole and only diet. The chief difficulty with the banana is that so often it is sold green, or partially so. One roll equals 100 calories; one pat of butter equals 100 calories; four of the ordinary Uneeda biscuits equal 100 calories; the lean portion of one lamb chop equals 100 calories; twelve double peanuts equal 100 calories; a piece of fish about the size of the palm of the hand equals 100 calories; a teaspoonful of peanut butter equals 100 calories; and so you can go through the whole list, reducing the commoner foodstuffs to a basis that anybody can understand. Extreme accuracy is not claimed for this plan but it does serve to give a fairly clear idea of what the individual should receive.

I used this method a part of last year with medical students and their own testimony was that they were able to get a clearer idea in fifteen minutes as to what was meant by caloric feeding by being able to visualize the articles, than they were by reading pages and pages of tabulations showing that so many grams of one thing equaled so many calories, and so many grams of something else equaled so many more calories. I intend to use the method this winter with dispensary patients to find out, in the first place, approximately how much food they are getting. It has been our experience that many of the patients who come to Phipps Institute are getting food which amounts to but 1,200, 1,500 or 1,800 calories when their disease demands that they should be getting about twice that amount; and quite as often as not you will find that their deficient dietary is not a result of the fact that they have not money enough to get the food, but because they are not purchasing the right kinds of food.

Whether a better method than this one can be devised for the teaching of dietetics among people who have no knowledge whatever of food values, I do not know. I do know this, that prior to my seeing this exhibit, I had a very poor idea as to what my daily food consumption was. I had not the slightest idea whether I was getting 1,500 or 3,000 calories, but with this method I can compute it with a fair degree of accuracy.

PREGNANCY AND PULMONARY TUBERCULOSIS

WITH A REPORT OF ONE HUNDRED AND THREE CASES *

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The incidence of pregnancy and tuberculosis is a frequent one. In 1913, Bacon estimated that 32,000 tuberculous women become pregnant annually in the United States, and added that between 44,000 and 48,000 women of the child-bearing age die of tuberculosis every year.

Among those who see much of pulmonary tuberculosis, it is a well recognized fact that, among women, this disease not uncommonly first manifests itself during pregnancy or shortly after the birth of the child. Why a tuberculous process should become active during pregnancy is not altogether clear, unless it can be ascribed to an added strain on the woman's resistance. In the cases following confinement, the violent exertion that characterizes many labors is commonly accepted as the probable cause of arousing to activity a latent lesion, the exertion under these circumstances being as harmful as mountain climbing or other forms of violent effort. Whether it is coincidence or whether pregnancy has any influence in rendering a dormant tuberculous process active may be debatable; but the fact that the association is of relatively frequent occurrence is common knowledge. For instance, among the women in the White Haven Sanatorium at the present time there are twenty-nine who have borne children; of this number, six, or 20.7 per

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* Read before the Philadelphia Obstetrical Society, Oct. 3, 1917.

* A preliminary report of some of these cases, and references from some of the literature utilized in this report, appeared in the American Journal of Obstetrics, January, 1916.

cent., date the onset of their tuberculosis from a pregnancy or shortly after the birth of a child.

Furthermore, the large number of women of child-bearing age who die of tuberculosis annually makes it apparent that during this age period the combination of tuberculosis and pregnancy is always a possibility. Unfortunately, this fact is not sufficiently appreciated; and unless the woman has definite pulmonary symptoms when she consults her physician regarding her pregnancy, little thought is given to her respiratory system. Too often the pregnancy is regarded as a normal physiologic process and, aside from examinations of the urine and blood pressure, little or no attempt is made to obtain information as to the woman's general health or her previous medical history. Many of the women who first manifest tuberculosis at this time give a history of having had a small hemoptysis, an attack of pleurisy or other symptoms or group of symptoms in the past that renders the possibility of latent tuberculosis being present very strong. Failure to acquire this knowledge of the patient's past illnesses, or failure to give such information due consideration not infrequently leads to disastrous results.

The history of pregnancy in the tuberculous woman is an interesting one. Years ago, pregnancy was supposed to exert a favorable influence on the course of pulmonary tuberculosis. This was doubtless owing to the fact that pregnancy in itself tends to increase the weight of the individual, and also that during the early months of pregnancy, gestation is less likely to result in deleterious changes to the tuberculous person than during the latter half of pregnancy. The fact that the cases were not closely followed is probably the chief reason for such a view ever having been held.

For studying such a question as this, a review of the literature is of especial value; and particularly valuable are those reports pertaining to series of cases in which the patients have been observed over a definite period of time. The following is a condensed summary of some of the most important articles appearing on this subject prior to 1917:

Lebert found that pregnancy had a bad influence on the course of tuberculosis in 75 per cent. of cases. Deibel found this to occur in 64 per cent. of cases, and von Rosthorn in 70 per cent. Von Bardeleben found this to be true in 71 per cent., and states that 47 per cent. of these patients died during pregnancy, labor or the puerperium. In all von Bardeleben's mild cases there was more or less, sometimes only slight, aggravation of symptoms during pregnancy or the puerperium, and in most of these cases, the acute symptoms subsided, at least to some extent, in from eight to twelve months. In his series, 16 per cent. were presumably closed lesions when the pregnancy occurred, 12 per cent. were severe or acute cases, and all exhibited an aggravation of the disease, especially toward the close of the pregnancy. Heiman's collected statistics showed that pulmonary lesions grew worse during pregnancy in 73.4 per cent. Pankow and Kupferle found that 94 per cent. of their patients with active pulmonary lesions grew worse. Reiche observed ill effects in 77 per cent., and Freund in 38 per cent. of cases. Fellner and Schauta found that a relapse occurred in 68 per cent. of quiescent or mild chronic cases in which the patients had been well for a considerable period prior to pregnancy.

The findings of Pradella (quoted by Schauta) were even less favorable. In a series of 1,035 cases, he found that 95 per cent. of the patients grew worse. Kunreuther also emphasizes the dangers incident to this condition. Marletti found that 50 per cent. grew worse during pregnancy; Kamina, 50 per cent.; Schauta states that in tuberculous guinea-pigs, pregnancy distinctly shortens the life of the animal. In the animal experiments of one of us (Norris), this was also found to be the case, and especially did this occur in the period following parturition. Schauta quotes the authorities from German sanatoriums to the effect that only 25 per cent. of tuberculous women were able to work four years after childbirth, and that not all of these cases were by any means cured cases.

Albeck of Norway found that of sixteen patients, all of whom were treated in private sanatoriums, and were therefore presumably the recipients of excellent treatment, six died within fifteen months. Essen-Müller reports that death or aggravation of symptoms occurred in 50 per cent. of his series of sanatorium patients. Schauta states that in at least 75 per cent. of all cases, the disease was aggravated as the result of the pregnancy. Ebeler, from a study of thirty-two cases, recommends the immediate emptying of the uterus unconditionally in every stage of tuberculosis and in any month of pregnancy. Parry reports that in her series of thirty-eight cases, all of which were of the severe type, 50 per cent. of the patients died within two months after labor. Fellner observed a general maternal mortality in 9 per cent. Osler quotes Dubois to the effect that "if a woman threatened with tuberculosis marries, she may bear the first accouchement well; the second with difficulty, and the third never."[1] Malsbary found the highest mortality among primiparas.

Bacon estimates that 33 per cent. of tuberculous women who become pregnant die in less than one year following labor. Hoffman found that the greatest mortality among tuberculous women was between the ages of 15 and 45 years (195.5 per hundred thousand population), indicating that many women die as the result of pregnancy and childbirth. Schlimpert asserts that the greatest number of deaths from tuberculosis during pregnancy occur in childbed (75 per cent.).

REVIEW OF EIGHTY-FIVE CASES

	No.	Per Cent.
Total number of cases (from the Henry Phipps Institute)	85	...
Improved	5	5.8
No change	69	81.1
Worse	2	2.3
Deaths	6	7.0
Pregnancy interrupted (therapeutic abortion)	3	3.5
Premature labor (spontaneous)	2	2.3
Miscarriage	4	4.0
Infants alive	63	...
Infants dead	13	...
Infants stillborn	1	...

We have been unable to trace four patients.

In a review of the foregoing statistics, a number of facts must be taken into consideration. A certain number of patients with pulmonary tuberculosis will exhibit exacerbations even when not pregnant, and this proportion must be deducted from the figures here given when the influence of pregnancy on the course of the disease is considered. On the other hand, statistics compiled from maternity hospitals from which patients are discharged in two or three weeks after labor, no further track being kept of them, are misleading in that no note can thus be made of the exacerbations occurring in the late puerperium or during lactation.

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[1] Some authorities attribute this statement to Louis.

The review of eighteen cases seen in the obstetric practice of one of us (Norris) confirms the foregoing statistics. Of these patients, 5.55 per cent. were apparently improved; 22.2 per cent. were unchanged; 61.11 per cent. were worse and 11.11 per cent. died either during the course of the pregnancy or the puerperium. As will be seen, these figures coincide closely with those found in the literature, but are not in accord with those observed by us at the Henry Phipps Institute, where in a series of eighty-five cases, two patients were worse and six died, or about 10 per cent. in which the pulmonary lesions were aggravated. Why, then, is this apparent discrepancy? A study of the statistics, as they appear in the literature, shows that the majority of these reported cases have not been reported by obstetricians. The majority of pregnant women are delivered either by the general practitioner or by the midwife, and only a relatively small proportion are seen by the specialist. It naturally follows that the specialist is called in consultation in the worst cases, and that the worst cases are likely to be sent to hospitals for delivery, where again they fall into the hands of the obstetrician. Thus the obstetrician is especially prone to see those patients that are doing badly, and this is doubtless a factor in the high mortality and morbidity as usually reported in this condition.

A review of the cases seen during the past five years at the Henry Phipps Institute shows that eighty-five pulmonary tuberculosis patients who have been pregnant have been observed.

A study of these results shows that, as previously mentioned, two patients were worse and six died. Pregnancy was interrupted three times on account of the pulmonary condition; of these, two patients were improved and one showed no change. Undoubtedly, a therapeutic abortion would have been performed on a few more patients but for the fact that many were seen for the first time late in their pregnancies when emptying of the uterus has little effect on the course of the pulmonary lesion. Cesarean section was done in one case:

> A woman with bilateral ulcerated lesions, frequent hemorrhages, hyperpyrexia, and rapid and weak pulse, in whom physical examination revealed evidence of the last stages of pulmonary tuberculosis, and the slightest effort was prone to bring on hemorrhage, was referred to the maternity hospital with the hope of nursing her along until pregnancy was so far advanced that a live child might be obtained. When within two weeks of term and after having been under observation for about six months, the patient's general condition became so bad that a fatal termination was expected almost hourly. With the hope of saving the child's life, spinal anesthesia was given and a rapid Cesarean section performed. The mother died a few hours later. The child was in good condition and left the hospital six weeks later in evident health, and had been gaining weight normally. At birth this infant weighed 7 pounds, and there was no cause, as far as we could determine, why it should not do well. At 6 weeks of age this infant was sent to a nursing home, where it subsequently died from an unknown cause.

In three of our cases, spontaneous premature labor occurred; one of these infants was dead, and the other children did well. Of the eighty-five cases, sixty-nine, or 81.1 per cent., showed no change as result of their pregnancy. The cases from the Henry Phipps Institute consist of about the ordinary run of pulmonary tuberculosis, and are not of the class usually seen by the obstetrician. These statistics, therefore, are of unusual value. We would especially point out the danger of drawing conclusions regarding the effect of pregnancv on the tuberculous individual from a small series of cases. Not only should a moderately large series be utilized for study, but the cases should be followed for a period of some months subsequent to delivery. It has been impossible in our cases to arrange them in periods of time. In some of the cases reported, the patients were recently delivered, and others had had one, two, or even three children.

Of the eighty-five patients, sixty-three infants are alive today, and fourteen have died. Much difference of opinion exists as to whether the infant of the tuberculous woman is or is not a hereditary weakling. It is our belief, based on a study of these cases and of a moderately thorough review of the literature pertaining to the subject, that these infants are not unusually weak, certainly not more so than would be expected from ordinary anemic mothers. Of course, taking a hundred infants born of tuberculous mothers and a similar number born of healthy sources, the latter would undoubtedly be the stronger set of children. The point we wish to make is that while the mortality in children born of tuberculous mothers is unusually high, this is due not so much to the fact that the children are in bad condition when born, but largely to the fact that they are often motherless, are usually bottle fed, and generally do not enjoy the same care as does the child with a healthy mother.

THE PROPER PROCEDURE

After all, the important point in this subject is the question of what should be done with the tuberculous pregnant woman. Undoubtedly, tuberculous women should be advised against conception in the ordinary cases. As a rule, however, the physician is not consulted until pregnancy has taken place. What, then, shall be his course? Time does not permit extensive discussion of this point, but we may thus summarize our views:

Prior to the fifth month of pregnancy, the uterus should be emptied in all cases which show either advanced or active lesions or in which laryngeal involvement develops. This point should be determined not only by the obstetrician but also by a skilled internist, familiar with pulmonary tuberculosis. After the fifth month, little advantage is gained by emptying the uterus; and it would be best to allow these patients to go to or nearly to term. Labor should be made as easy as possible. With this end in view, induction of premature labor is often advisable. Forceps should almost always be employed, and especial care should be given to the question of anesthesia. In nonactive lesions of a moderate grade, ether, in the opinion of one of us, is the safest mode of producing the anesthesia. The question of the use of spinal anesthesia in these cases naturally arises, and if this form of anesthesia has any place, it is certainly in cases of advanced pulmonary tuberculosis when anesthesia is absolutely necessary. Immediately after birth, the child should be taken from the mother and should not be allowed to nurse. The dangers of infection to the child are very definite ones. In rare instances, tubercle bacilli have been demonstrated in the milk of women suffering from pulmonary tuberculosis. A greater danger is the contamination of the nipples or child's mouth with the tubercle bacilli by the mother's hands. Even were it not for the fact of the danger to the infant from nursing, artificial feeding should be resorted to, as our efforts should be to conserve the mother's strength in every way possible. After delivery, the dangers to the mother are by no means passed. Indeed, many authorities consider the puerperium the most hazardous period.

The problem of the pregnant woman who is also tuberculous is often a difficult one. Many maternity hospitals do not admit such patients, or if they do it is only after considerable persuasion has been used, and then only a week or so before the expected confinement. The same thing is true of the tuberculosis sanatoriums. Many of these institutions distinctly specify that they will not admit such patients. The result is that the social service departments are in a quandary as to how to dispose of them. In the interests of these women, the majority of whom are amenable to improvement so far as the tuberculosis is concerned, it is highly desirable that both the maternity hospitals and the tuberculosis sanatoriums be encouraged to care for them.

CONCLUSIONS

1. The combination of pregnancy and pulmonary tuberculosis is a frequent one.
2. Pulmonary tuberculosis exerts little or no influence against conception.
3. Pulmonary tuberculosis exerts but little influence on the course of pregnancy, and except in the advanced stages exerts little or no influence toward causing abortion, miscarriage or premature labor.
4. About 20 per cent. of mild, quiescent pulmonary tuberculosis, and 70 per cent. of more advanced cases exhibit exacerbations during pregnancy or the puerperium.
5. Marriage is worse for tuberculous women than for tuberculous men, owing to the dangers incident to pregnancy.

6. Unless the pulmonary lesions have been quiescent for a moderately prolonged period, tuberculous women should not marry.

7. Tuberculous women should not become pregnant unless the disease is in the first stage, and has been quiescent for a minimum period of two years.

8. It is as yet impossible to determine with certainty which patients will bear the added strain of pregnancy well and which badly. We must individualize our patients. Moderately extensive lesions, recent activity, the development of secondary lesions, especially laryngeal involvement, loss of weight, fever, hemorrhage, sweats, lack of vigor, and inability to obtain proper treatment are ill omens, whereas the reverse are more favorable.

9. Prior to the fifth month of pregnancy, the uterus should be emptied if the disease manifests evidence of becoming active, or if the lesions are extensive ones or laryngeal involvement occurs. Curettage during the first six or eight weeks, and in the latter cases vaginal hysterectomy, are as a rule the preferable methods. Interruption of pregnancy does not insure an amelioration of the pulmonary condition, but does definitely improve the prognosis. About 65 to 70 per cent. of patients, prior to the fifth month of pregnancy, will be definitely improved by the emptying of the uterus as soon as acute symptoms arise, provided proper after-treatment is carried out. Late intervention has given less satisfactory results. Sterilization is rarely justifiable.

10. After the fifth month of pregnancy, it is generally advisable to treat these patients expectantly. Labor should be made as easy as possible. For this end, induction of premature labor two weeks before term is often advisable; rarely, if ever, should they be allowed to go beyond term. At labor, forceps or version is usually indicated.

11. Infants should not be nursed by tuberculous mothers, and should be especially guarded from infection.

12. Hygienic and dietary treatment should be employed at all times. These patients should be kept under close observation and should be examined by a competent internist at regular and frequent intervals.

13. In the great majority of cases the tuberculosis precedes the pregnancy. Even in those cases in which the symptoms are first observed during pregnancy, infection has generally occurred prior to conception, and an exacerbation during pregnancy has directed attention to the pulmonary condition.

14. We especially urge that all pregnant women giving a history at all suggestive of pulmonary tuberculosis be subjected to a thorough examination by a competent internist at the earliest possible date. Only in this way can the proper treatment be instigated at the time when it is most valuable.

15. It is doubly important that tuberculous pregnant women shall be given the same care as the nonpregnant person as far as rest, hygiene, diet, etc., is concerned.

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CHEMOTHERAPY IN TUBERCULOSIS.[1]

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In its previous lectures on the general subject of tuberculosis the Harvey Society has been especially fortunate.

Speaking on the subject of tuberculosis in 1906, Theobald Smith said, "The present-day problems in tuberculosis which can be approached by experimental or at least by laboratory methods manifest themselves in three different ways:

"1. In the somewhat chaotic condition of opinion concerning the avenues through which tubercle bacilli gain a foothold in the body.

"2. In the wide divergence of opinion concerning the relation of bovine to human tuberculosis.

"3. In the general trend of studies toward the problem of specific immunity, with especial reference to prevention and treatment."

He presented and critically considered the evidence bearing on the portals of entry of the tubercle bacillus and laid stress on the major significance of the direct infection of the lung and associated lymph nodes by way of the inspired air.

Two years later Calmette presented a great deal of material bearing on the proposition that the tubercle bacillus gains its entry chiefly through the intestinal mucosa. Today opinion on these subjects is perhaps little less chaotic than at the time of these lectures, but the debate has largely subsided, due to a paucity of competent new evidence.

As the result of exhaustive experimental work in this country and abroad the relation between bovine and human tuberculosis may be considered to be established.

The third group of problems considered by Theobald Smith has been continuously attacked in the interim. The accomplishments of the period were summarized in able fashion by Baldwin two years ago. While immunization has so far led to no practical result in tuberculosis, we should not consider for a moment that the possibilities are exhausted. In the abstract, immunization in some form—active immunization as a preventive measure or combined passive and active immunization during the course of the disease as a therapeutic procedure—most closely simulates nature's own method. If in tuberculosis we have so far achieved no appreciable success along these lines it is doubtless that success awaits some new technical departure adapted to the exact situation, a development that may come with a fresh point of view derived from the study of some other more or less distant disease or which may more probably come as a matter of direct attack if the search is pursued with energy and in a spirit of independent inquiry.

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[1] Lecture delivered before the Harvey Society of New York, November 25, 1916.

Turning to the subject of chemotherapy in tuberculosis it should be plain that the term is used here and can only be advantageously used in the restricted sense in which it was introduced and employed by Ehrlich—not easy of concise definition—but conveying the implication of biological experimentation carefully coördinated with constructive chemical manipulation, and even, if necessary, chemical research of a most advanced type. This use of the term is emphasized because of late the word chemotherapy has become fashionable as applied to the empirical therapeutic use of any chemical substance from arsenic for gastric ulcer to zinc sulphate for dysentery; a use chiefly designed to conceal an utter absence of either thought or intelligent experimentation. Employing the term in the restricted sense I hope to do little more than to show that it may be properly employed in connection with research in tuberculosis. Even in this I can barely carry conviction as measured by any definite success in the treatment of experimental tuberculosis.

Historical considerations, on the other hand, would allow to the worker in tuberculosis, a certain proprietary freedom in the employment of this word, and especially the real conception it represents. Ehrlich once stated that he counted as most memorable the evening on which he heard Robert Koch describe to the Berlin Physiological Society his researches culminating in the discovery of the tubercle bacillus.[2] Koch after this discovery at once applied himself with characteristic vigor to the discovery of a disinfectant which should act to rid the body of this destructive invader. The idea of a chemical disinfection of the body was prominent in the early writings of von Behring. As Behring and Ehrlich were at this time most closely associated with Koch (it was Ehrlich who first showed how the tubercle bacillus could be easily stained), who can doubt that this idea was a dominant one and shared more or less equally by all three in those days. All were involved, each in his separate way, in the epoch-making discoveries in the realm of immunization, the theoretical development of serum therapy and its practical employment. Ehrlich alone persisted in the original idea, and finally achieved a surpassing success. This early idea then of a chemical disinfection of the body, let us examine it somewhat more closely as to what it was at its inception supposed to involve—and then see what of an essential nature had to be added to it in order to arrive at a successful result.

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[2] "Es war in einem kleinem Raum der Physiologischen Instituts, als Koch in schlichten und klaren Worten unter Vorlegung zahlloser Präparate und Beweisstücke die Atiologie der Tuberkulose mit überzeugender Kraft darlegte. Jeder, der diesem Vortrage beigewohnt hatte, war ergriffen, und ich muss sagen, dass mir jener Abend stets also mein grösstes wissenschaftliches Erlebnis in Erinnerung geblieben ist." Ehrlich, Robert Koch, Frankfurter Zeitzung, June 2, 1910.

In Koch's writings, and in those of v. Behring of somewhat later date, it was considered possible that any disinfectant might probably act in a favorable way on bacterial infection. Many substances were examined for their disinfectant action and those found active in this sense were tried on the animal in the face of the experimental disease. Koch soon emphasized as an *a priori* consideration, the probability that a substance need not actually kill the bacteria in the body; if it would only restrain the growth of the parasite, the natural body defenses might be sufficiently aided so that cure could be attained. But even with this limitation every attempt resulted in disappointment, the stumbling-block apparently being the relatively high toxicity of the chemicals tried for the complex host as against the more limited organization of the parasite.

In a paper by Boer,[3] an assistant of Behring's in this early period, is found the germ of a most important development of this early and rather crude conception. Boer found in the course of an examination of a series of substances for their disinfectant action against a number of species of bacteria that most of them acted with a certain intensity which was of equal value against all the bacteria tried. Thus, phenol is weaker than bichloride of mercury and is weaker in the same degree no matter which microörganism is used as a test object. Methyl violet, on the contrary, was found to be seven times more active against B. anthracis than against B. diphtheria. These two bacterial species being equally susceptible to phenol, mercuric chloride and a number of other common disinfectants it is evident that in a very limited sense methyl violet is a specific disinfectant for B. anthracis.

When Ehrlich after the immunity period again turned his attention to chemical disinfectants he was naturally interested in the study of those substances exhibiting specific activities. Working with Bechold,[4 5 6] he studied a series of halogen derivatives of phenol and naphthol from this point of view. Very striking instances of this "partial specificity" as they designated it were uncovered. Without going into detail, it was shown that rather trivial chemical modifications, could profoundly alter the specific features of disinfectant action. Similar series of closely related chemical compounds have since been studied from the same viewpoint by Jacobs, Heidelberger, Amoss and Bull, at the Rockefeller Institute.

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[3] Behring, Gesammelte Abhandlungen, Leipsig, 1893, p. 198.

[4] Ztschr. f. Phys. Chemie, 1906, xlvii, 173.

[5] Ztschr. f. Hyg., 1909, lxiv, 113.

[6] Disinfektion, Paul Ehrlich (Festschrift), Jena, 1914, p. 505.

At present work of this nature is somewhat in discredit because of the profound disappointment which has resulted from most attempts to apply substances showing exquisite action in the test-tube to the more complicated situation they face when exposed in the animal body. I believe that such discouragement is premature. We are forced to admit now that which we must have foreseen, that test-tube action and *in vivo* disinfection do not go hand in hand. But of all the guides available to the intimate relation of chemical agent to parasite the study of the specific qualities of disinfectant action is the most logical, and I venture to predict that in due time in some quarter an important success will be credited to the application of this fundamental conception. In fact, if we may accept the report of Schiemann[7] such success has already been achieved in its essentials. It is stated by this observer that salvarsan, showing limited curative properties against experimental infections with the anthrax bacillus and the bacillus of swine erysipelas, has definite specific disinfectant action against these bacteria as contrasted with other species whose infections are not therapeutically influenced.

Let us leave for the moment this question of the application of *in vitro* disinfectants to the problem and turn to the first actual success achieved by Ehrlich in the treatment of an experimental infection. The benzidin dye trypan red was found capable of curing trypanosomatous infection in mice. Trypan red has very little if any action in shortening the life of the trypanosomata when the exposure is made in the test-tube. It therefore became apparent that success in this field could be achieved by leaving aside the disinfectant qualities of substance *in vitro* and proceeding at once to the crucial test of the animal experiment with a wide variety of compounds.

If now we ask ourselves why those substances acting as disinfectants in a somewhat specific sense fail to rid the animal body of bacteria, while other substances, hardly disinfectants in any sense, are therapeutically active in a more or less specific way, the answer is in part obvious and involves important principles which must be kept constantly in mind in all chemotherapeutic experimentation. When substances active *in vitro* fail *in vivo* it is frequently because they are so distributed when introduced into the animal body that they fail to come in contact with the parasite at all. The substance is quickly eliminated in some cases, is quickly and completely destroyed in other cases, has in still other instances higher affinities for the constituents of the body fluids or cells than it has for the microörganism in question, affinities which may or may not be put in evidence by actual acute or chronic intoxication. When, on the other hand, apparently indifferent substances are found to be therapeutically active it is because in the chemical melting-pot of the animal body, new compounds, active and with the required distribution coefficient, are produced either from the substance itself or under its influence. These two series of qualities of substance, their capacity for specific antiparasitic action and their relation to the complexities of the animal body as evidenced by what can be found out or inferred in regard to their distribution in the body, are basic in the conception of chemotherapy.

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[7] Ztschr. f. Immunitatsforsg., 1914, xxiv, 167.

When in any particular instance an attempt is made to elucidate these fundamental qualities, purely technical questions of decisive importance come into the foreground. Again, a consideration of Ehrlich's work shows most clearly what is required. It is apparent in the first place that only these diseases can be approached in this way in which the fundamental etiological relationships are cleared up with such results that we are left with a very precise method of experimentation involving in the animal the essential features at least of the pathology of the human disease. The trypanosomiases as studied by Ehrlich are almost ideal from this point of view. The local lesions in tissues are not prominent, the infection can be made to run a rapid and invariable course, the progress of the disease can be precisely followed from day to day by a very simple microscopic examination of the blood, and the animals of choice are small and inexpensive to purchase and maintain. If these cases are defective —and I think they are in some measure—it is in that the pathology of the experimental disease localization of the parasite in particular tissues does not occur as it frequently does in the spontaneous disease, and there is little local tissue reaction. Questions involving the distribution of the chemical agents are consequently much more simple. It is possibly because of this fact that the experimental results have not been duplicated in a striking way in their practical therapeutic application to such conditions as sleeping sickness.

Finally, in the person, in the surpassing mental attainments, of Ehrlich another essential limitation to this form of experimentation was overcome. Coöperation so essential to achievement in every walk of modern life is more apt to materialize as between the various functional units of one man's mind than as between individuals. The united efforts of a trained chemist and a highly accomplished biologist were assured beyond possibility of even temporarily strained relations by the peculiar qualifications of this man of genius. The progress of chemotherapeutic research is contingent on a similar happy conjunction in the human mind and hands of accomplishments in these widely separated fields of research. Whether the limitation which the subject faces in consequence will in the future be surmounted by activity of individuals trained in selected parts of both fields or by the mutual and coöperative activity of specialists in the separate sciences can only be left to the chances of the future.

Having so far considered the place of chemotherapy as related to the various other possibilities of research in tuberculosis, I turn to the immediate subject of the hour. I wish very briefly to consider the facts of experimental tuberculosis in order to show what are its disadvantages and its advantages as a basis for chemotherapeutic study.

The tubercle bacillus as cultivated in the laboratory occurs in three types showing constant qualities: the human, the bovine, and the avian. With the latter we are not now concerned. With either the human or the bovine type, most warm-blooded animals, all those certainly that are commonly used in the laboratory, may be infected and the infection will run a regular course, terminating in death in many instances. The experimental disease certainly involves the essential features of the human disease. At first sight, then, the requisite conditions underlying therapeutic experimentation are already at hand. I say at first sight because, in the minds of the general medical public and those laboratory workers whose experience with tuberculosis is casual, relative certainty of result speaking generally, has been exalted to an almost mythical conception of absolute certainty in each particular case, a fundamental misconception responsible for disappointing mistakes and perhaps actual harm.

Any single culture of the tubercle bacillus is a relatively constant quantity; but, as in all other species of pathogenic bacteria, individual cultures differ in particulars which are of critical value when they are to be used for advanced experimentation. Attempts to modify the properties of particular cultures in any given or constant direction as a matter of controlled experiment have for the most part failed, yet over periods of years and due to conditions accidentally arising a culture may profoundly change its qualities. Thus, Krause has recently conducted certain experiments which depended upon his possession in the laboratories at Saranac Lake of cultures showing constant differences in virulence, particularly one which now produces in guinea-pigs a disease which progresses for a period and then tends to heal spontaneously. With any given culture at a given time the amount inoculated and the manner in which the inoculation is made are of decisive importance to the result. With a certain culture of human type in a recent experiment of my own, $\frac{1}{10}$ mg. was inoculated intraperitonially into 15 guinea-pigs.

The first of these died in eighteen days, the fourteenth died on the thirty-sixth day, and the last one lingered until the sixty-fifth day. In a subsequent experiment 14 guinea-pigs were inoculated in the same way with one-half the amount of the same culture ($\frac{1}{20}$ mg.). Of these the first died on the twentieth day; 8 were alive on the fortieth day; 4 remained on the sixtieth day; 2 still live on the nintieth day. If the amount of this culture inoculated were still further reduced we would doubtless come to a point when some animals would die and some would live for an indefinite time or perhaps recover entirely from the disease. By inoculating larger doses of this culture no doubt it would be possible to arrange an experiment in which all of the animals would be dead by the end of four weeks.

These results, conversely stated, emphasize the fact that with the same amount of culture inoculated in the same way there is a great variation in the length of time the animals may be expected to survive. With guinea-pigs I have yet to conduct such an experiment in which the last animal did not live at least twice as long as the first to die, and often the difference is much greater than this. If the inoculation is made subcutaneously this variation is increased. If it is made intravenously in guinea-pigs it is apparently not greatly, if at all, diminished. By attention to the weight and age of the animals the variability in result as to individuals is kept at a minimum, but it is always a large factor. These facts make it plain that any experiment designed to test the therapeutic activity of a substance must be so arranged as to permit of statistical interpretation finally. The probable individual variation must be completely accounted for in each experiment. This means that a considerable number of animals must be used for each substance brought under consideration and at least as many for the requisite checks. Just how large this unit group should be has probably not been satisfactorily determined even yet.

You will have noted that the actual time involved is considerable. Thirty days is no short period and ninety days is one-third of the conventional laboratory year. Contrast this with the four days of the typical animal experiment in Ehrlich's work with trypanosomata and it is self-evident that we have here a very distinct handicap on the application of the chemotherapeutic idea to tuberculosis work.

Efforts have been repeatedly made to discount in whole or in part the variation in the length of time animals live after such inoculations by terminating the experiment on a certain date through slaughter and postmortem examination. Postmortem examination of the animals dying spontaneously reveals a variation in the exact condition of the organs which is fully as great and in my opinion considerably greater than that shown in the length of life in days. One animal dies because the liver is completely degenerated, another because the lungs are consolidated, a third is drowned in his own fluids, showing more or less local disease widely distributed, an intense edema of the lungs and the pleural cavities completely filled with fluid exudate. These conditions, if they are to be interpreted, must also be considered statistically, and this if it is to be done must involve an even larger material than when the resistance of the animal is accounted for as a single factor. Such attempts at a short cut on any scale so far attempted are quite unsound. In any experiment, after all of a sufficient group of controls are dead and accounted for, not before then, a considerable amount of guidance may in the future be obtained from the condition of the organs of killed or dying animals.

Similarly, reliance has been placed on the presence or absence of large numbers of tubercle bacilli in the lesions or apparently healthy tissues of animals dying within the period of life of controls. If an animal dying in this period shows few lesions or none, and if tubercle bacilli are found only in small numbers, it may sometimes be safe to conclude that death was not due to tuberculosis and the animal can properly be excluded from consideration. But in the presence of moderately extensive lesions it must be assumed that an animal may be as apt to die from the consequences of a largely successful effort to remove bacilli, as from the presence of the microörganism *per se*. After the last control has died the presence or absence of bacilli may have great significance in the experiment. Previous to that time, at least until much more extensive observations as to the variability of this factor have been made, opinion based on this point has no value.

Two things then, the absolute time involved in each experiment and the size of the experiment, as conditioned by the number of animals which must be used to cover individual variations, are the essential factors of difficulty that stand in the way of the application of the principles previously considered to tuberculosis as an experimental disease. Can the difficulties so imposed be directly overcome? As abstractions, very easily; as a practical matter it may easily involve a concentration of trained effort and an expenditure of money beyond that so far applied to the study of any single problem in medical science to assure an even chance of success.

It has seemed to me quite possible that the issue presented might be treated by avoiding it. I have spent a considerable amount of time in the study of various forms of local tuberculosis and of general tuberculosis in animals other than the usual guinea-pigs and rabbits, in the hope of encountering a form of the disease which would be less variable or run a shorter course than I have indicated. Most hopeful for a time seemed the study of a tuberculosis of the cornea in rabbits. With Dr. Montgomery I studied rather more in detail this interesting local disease than had previously been done. On a small scale it seemed ideal for our purpose. When, however, the test came to be made more largely it was found that the individual variation in reaction was as great as in other forms of experiment and that certain other factors were introduced which added to the difficulty. We were dealing here with an open lesion, and this very frequently became infected with extraneous organisms. Moreover, there is a constant discharge of bacilli from the purulent conjunctival sac, and unless the experiments can be segregated, the animals being cared for by already tuberculous persons, there is the constant likelihood of complicating other experiments in progress and a continuous menace to the health of one's employees. The possibilities of similar studies of other lesions or of the disease in other animals are not at all exhausted and such efforts should prove profitable in the future.

Offsetting the disadvantages which have been pointed out as inherent, tuberculosis offers an interesting opportunity quite peculiar to itself. The multiplication of the bacillus in typical instances is accompanied by a local rearrangement of the body cells to form nodular lesions readily visible to the naked eye and of characteristic structure microscopically. These nodules, the tubercles, can be used as a guide in the study of the distribution of extraneous chemical compounds to the neighborhood at least of the bacteria. The tubercles, if necessary, can be picked out and examined chemically, or more practically, for a beginning, colored substances can be chosen as the starting-point of combined chemical and biological research. These can, under favorable circumstances, be immediately recognized in the tissues, and questions of distribution can be rapidly answered by their use.

On the occasion of a visit to Baltimore four years ago I was shown some very beautiful preparations by Dr. Winternitz, preparations made in a study of the origin of the cells taking part in the reaction of the earliest hours after an infection of the animal with tubercle bacilli, and since carefully described by Bowman, Winternitz, and Evans.[8] My interest was aroused in the possibility of making a wider application of the so-called vital stains, and I shortly found by experiment that the fibrocaseous tubercle took up certain of these stains in a characteristic way. The results of these early experiments were recorded and summarized in the following terms:

"The first of these experiments shows again the selective action of Isaminblau for the large mononuclear phagocytic cell as pointed out by Goldman. These cells are found abundantly in the peripheral portions of fibroid tubercles.

"The second experiment is of great interest, showing, as it does conclusively, that extraneous chemical substances of proper constitution may within a few days penetrate to the caseous centre of a tuberculous mass and become concentrated there in greater degree than in the normal surrounding tissues. The particular substance used in this experiment, trypanroth, may probably be without effect on the lesion itself, but the result should be a great stimulus to the future work in a similar direction."[9]

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[8] Centralbl. f. Bkt., 1912, I Orig., lxv, 403.

These experiments seemed to me to be of the utmost importance as a basis for further experimental work of a coördinated chemical and biological nature. The opinion had been quite generally expressed that as the tuberculous tissue was without internal blood supply it could be reached only with difficulty if at all by medicinal agents which might be made to circulate in the blood stream. Such an opinion, if to decisive weight, would make it appear to be an unreasonable waste to experiment largely with the idea of developing general medicines which might be hoped to influence the local tuberculous process. The actual result, on the contrary, rendered such experimentation reasonable, and, as it seemed to us, eminently desirable.

DeWitt[10] in this country and v. Linden[11] abroad reported somewhat later on similar observations made independently with methylene blue. DeWitt confirmed my particular observations, reported on a number of dyes which failed to appear in the tubercle, and added trypan blue to the list of penetrating substances. I have since found, in the course of observations, so far unpublished for the most part, that a considerable number of azo dyes related in their chemical constitution to trypan red and trypan blue penetrate the tubercle in this way. DeWitt has since used methylene blue as the starting-point for a series of studies intended to serve the same purpose as those I am about to consider.

These observations served as the starting-point of a series of researches in our laboratory which are being continued at the present time with the object of finding or building up substances which shall have this penetrating quality well developed, and which shall at the same time be possessed of physiological activity of such nature that they might be expected to act favorably on the tuberculous process. If this effort should result in any measure of success the credit would be shared by me with Mr. Robert B. Krauss, who has been continuously associated with me for four years, and who has been responsible for all of the purely chemical work carried out.

The first concrete problem outlined on the basis of the considerations above outlined was to take the dye trypanroth, which had been used in the more striking of the experiments commented on, and try by chemical manipulation to form from it, or with it, a substance having physiological activity while preserving the qualities which enabled the dye to penetrate the tubercle.

Mr. Krauss undertook to make as many modifications of trypan red as he could, following certain general lines.

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[9] Arch. Int. Med., 1912, x, 68.

[10] Jour. Infect. Dis., 1913, xii, 68.

[11] Beitrage z. Klinik d. Tuberkulose, 1915, xxxiv, 1.

1. The staining qualities of the substances were to be at least in part preserved.

2. The preference was to be given to substances containing iodin, phenolic substances, or certain other constituents.

These specifications were drawn up on very general grounds, some of which may be stated as follows: Iodin was selected because of the long-standing belief among medical men that iodin was of some favorable influence on the progress of tuberculosis when applied locally either as an element or as iodoform; carbolic acid, guaiacol, and other phenolic substances were known to be relatively active disinfectants against the tubercle bacillus, and some of them also enjoyed a reputation as medicines for this disease. The staining qualities were to be preserved as far as possible as a guide to the localization in the course of the subsequent animal experimentation.

The chemical work involved was successful. In the course of a year and a half about seventy-five compounds were secured on the plan outlined. The chemical manipulations and results were published by Krauss.[12] These preparations were used in a preliminary way in animal experiments and some interesting observations were made. In general it was indicated that none of the substances exerted any curative influence on experimental tuberculosis. Some of them seemed, however, to have a definite influence on the vigor and rate of the formation of bloodvessels and connective tissue in and around the tuberculous process, the tests being made on the rabbit cornea.

The plan had been to prepare enough of each substance for a moderate amount of preliminary experimentation and then to make again those which seemed useful for further work. About the time the preliminary study of these compounds was completed the war arose and necessitated a change of plan. We had been purchasing trypan red from abroad and further regular supply was cut off. What was on hand and the occasional lots since secured we have used in a study, so far uncompleted, of the composition of the substance with view to its manufacture.

I have already said that following our observation that the tuberculous tissue in the living animal was easily penetrated by trypan red, many other dyes of the same general class, chemically speaking, were tested for their reaction in this particular. A considerable number were found which could become concentrated in the diseased tissue to a greater or less extent. Many of these had never been accurately described from a chemical point of view, others presented difficulty of manufacture beyond our means. After much consideration a dye known to the trade as Niagara blue 2B (benzidin + 2H acid) was chosen as the starting-point of a second attempt to construct a series of iodin and phenol compounds.

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[12] Jour. Am. Chem. Soc., 1914, xxxvi, 961.

It has been necessary, owing to the state of the market, for us to build up this substance from the raw products. This has been accomplished and a considerable series of compounds made by adding iodin and phenolic substances to Niagara blue have been studied, with rather meager results, which I shall not comment on now.

Covering about the same period of time as these studies on the relation of the vital stains to the diseased tissue, and in the hope of acquiring information which should in some measure guide that work, we have been studying the disinfectant action of various substances for the tubercle bacillus. We have hoped to uncover substances having the partially specific action discussed in the earlier paragraphs of this paper. Much time has been spent over methods. The procedure by which the results here considered were obtained was to determine the least concentration of the substance in glycerin-boullion, which would definitely inhibit the growth of the tubercle bacillus.

Because of the relation to the work outlined in considering the subject of the vital stains, we have so far paid particular attention to anilin dyes. We have also considered the more common disinfectants and some substances which are used in the building-up dyes. In order to get an idea of the specific qualities of the inhibiting action of the substances tested the typhoid bacillus was at first used in comparison with the tubercle bacillus. Very recently in the course of some work being carried out for the Pneumonia Commission of the city of Philadelphia I have gone over the whole field again, using the pneumococcus and staphylococcus aureus. Several hundred substances have in this way been examined with the following general results:

I. The growth of the typhoid bacillus is, with few exceptions, if any, less readily inhibited by anilin dyes than that of the pneumococcus, staphylococcus aureus, or the tubercle bacillus.

II. The triphenylmethane dyes, as a group, inhibit the growth of the pneumococcus and staphylococcus in dilutions which do not inhibit the tubercle bacillus. Among themselves these dyes vary greatly in the concentrations at which the four species are affected, both absolutely and relatively.

III. The azo dyes as a group inhibit the growth of the tubercle bacillus more readily than that of either pneumococcus or staphylococcus aureus. Again, there is a great relative and absolute variation in the effective concentrations. In the extreme instances in this group the tubercle bacillus is one or two hundred times as susceptible as the pneumococcus, and it seems proper to consider that the inhibitory power is in large measure specific.

IV. The other great groups of dyes give less striking results, the oxazines and thiazines, to which methylene blue belongs, are more active against the cocci; the eurhodines, with neutral red as an example, are more effective against the tubercle bacillus.

Certain other points developed by this work deserve passing mention. Many dyes, the majority perhaps, stain the growing membrane of the tubercle bacillus with greater or less intensity. The inhibitory power of the dyes is not at all, however, a function of this capacity to stain the membrane, nor is it a function of any particular staining quality of the dyes for silk, wool, or cotton, so far as we have been able to determine up to the present; nor of the solubility of the dye in alcohol or oil as compared to water. A small amount of work so far carried out indicates that among organic compounds other than the dyes, substances exist showing the same variable capacity to restrain the growth of the tubercle bacillus. Also a very limited number of experiments indicate that this capacity to restrain growth is not directly related according to any uniform or simple rule to the true disinfectant or lethal action of substances. Much more work will be required before these observations can be interpreted in terms of previous work with disinfectants.

Thus, approaching our problem from one point of view we have found a number of substances capable of penetrating tuberculous tissue and consequently having, as it seems to us, at least a slightly better chance of acting as antibacterial agents in tuberculosis than those which cannot so penetrate the diseased tissue. From another point of view we have found many substances possessing in marked degree and in a partially specific way the ability to greatly restrain the growth of the tubercle bacillus in the very limited conditions of the test-tube.

It has for some time back been a matter of serious effort with us to bring these two sets of qualities together in the same substance. We have had a definite though limited success in this effort. The dye Niagara blue 2B can be made to enter into chemical combination with various substances, iodin, phenol, certain fatty acids, and the like. The resulting products are apparently definite chemical compounds. As a rule they are dyes and with properties noticeably different in one or more particulars from the original substance. As a general thing the inhibitory capacity against the cultures is distinctly increased; the capacity to enter the tuberculous tissue is, on the contrary, usually lost entirely or greatly diminished. In one instance so far a condensation product of Niagara blue with formic acid, the partially specific inhibitory value, is raised about twenty times, from $\frac{1}{5000}$ to $\frac{1}{100000}$ the staining qualities for tuberculous tissues being in large measure retained.

Again, in studying the inhibitory power of various dyes, Mr. Krauss has constructed a long series of compounds, not new in principle, but for the most part never before made, according to the following scheme: Benzidin monosulphonic acid is so treated as to diazotize its free NH_2 groups. There is then added under proper conditions a quantity of the variant substance calculated to react completely with one of the NH_2 groups. When the reaction is complete there is added sufficient amidonaphtholdisulphonic acid (H) to react completely with the other NH_2 group. In this series we have also encountered a number of dyes possessing distinct inhibitory powers. Very few members of the series, so far as it has yet been extended, have any staining qualities as applied to the tissues of the living animal. When crude creosote is used as the critical component, however, a mixture of closely related dyes is produced in which both qualities are present in marked degree. These products are violet-blue dyes, staining the connective tissues of the living animal with moderate intensity and penetrating the tubercles very well. The inhibitory power of the mixture is stated in our terminology at 100000 or about one hundred times that of the dyes trypan red and trypan blue, which were the starting-point of our work in this direction. Partial specificity is also manifested by this preparation.

The accomplishments of our laboratory up to the present in the endeavor to study tuberculosis from the chemotherapeutic point of view can then be summarized in a sentence: we have built up several substances which in the test-tube are capable of restraining the growth of the tubercle bacillus in marked and measureably specific degree, and which when injected into the living tuberculous animal are capable of penetrating to the centre of the masses of diseased tissue.

Attractive as may be the plan by which these substances have been reached it would still be only the happiest accident if their further qualities were such as to render them active against the progress of tuberculosis in the animal body. Neither would the failure of two such substances mean that the idea is fruitless. For the present therefore our efforts in the chemical laboratory are directed toward increasing the number of substances possessing these (as it seems to us) fundamentally desirable qualities. We have also turned ourselves seriously to the testing of the possibilities of these substances and their relation as therapeutic agents. The latter phase of our work is scarcely begun and I shall pass it by with but few words.

Drawing on the literature for precedents I may cite the following studies as the most striking of the available examples:

1. Koch and his pupils in repeated experiments during the years 1890–1897 demonstrated that by the use of tuberculin the life of guinea-pigs infected with considerable amounts of pure cultures of the tubercle bacillus could be definitely prolonged. These tuberculin experiments are worthy of the most serious consideration. The same result was reported by a number of different observers at the time and I find no contradictory experiments. The exact chemical nature of tuberculin has never been determined

and it is to be presumed that its action comes within the field of immunity reactions rather than that of chemotherapy. I have included this substance in this brief discussion because I believe that the results with it are the best available standard on the basis of which the value of other results may be estimated.

2. Von Linden[13] in 1912 and again in 1915 presented tables showing that by the use of compounds or mixtures containing copper; or copper and methylene blue; or copper, lecithin, and cod-liver oil as a salve, with or without the separate administration of iodized methylene blue, the life of tuberculous guinea-pigs could be prolonged. The results as presented compare favorably with those gotten earlier with tuberculin, but in no way surpass them. Attempts to repeat some of the experiments by Corper in this country failed and Selter abroad has denied their significance.

3. Certain tables published by DeWitt[14] (1914) may be interpreted as evidence that copper and mercury compounds (or salts) of trypan blue can act favorably on the progress of tuberculosis in guinea-pigs, although the author does not put forward any positive claim for them. DeWitt has since stated publicly that she had obtained more definitely favorable results with a mercury compound of methylene blue.

4. Koga[15] (1916) believes he has attained results of value with a compound containing copper and cyanogen. On the face of the evidence again, this substance produces a result comparable to tuberculin but not surpassing it.

5. In the case of the two substances whose development in our hands I have described above, the one, that made by condensing formic acid with Niagara blue, has done only harm in guinea-pig experiments so far. In this it corresponds to Niagara blue itself. The diazo creosote compound seems in preliminary experiments to be capable of extending the period of life of infected guinea-pigs in certain instances. The percentage of animals favorably affected in any series is less than in the tuberculin experiments of Koch's co-workers.

Those critically inclined need not search far in the original accounts given of any of these experiments to find ground for denying that they are of significance. Such criticism has been offered and will certainly be continually forthcoming. Insofar as attempts have been made or are being made to introduce any of these substances into the practice of medicine, any amount of skeptical opposition is in my opinion fully warranted. In 1890 it was quite justifiable to take the first favorable results obtained in the laboratory and make careful clinical trial of tuberculin. We should, however, profit by this experience and proceed with great caution in the clinic until the evidence shows that new substances are distinctly better than tuberculin experimentally.

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[13] Loc. cit.

[14] Jour. Infect. Dis., 1914, xiv, 498.

[15] Jour. Exp. Med., 1916, xxiv, 107.

In the interest of scientific progress, on the other hand, all of these results should be treated with great charity. In view of the purely statistical nature of the inquiry, the experiments must be repeated a number of times before they are finally accepted as evidence, but it must be remembered that a single failure has no more interest than a single success. If it be granted as a probability that some measure of the truth may lie in these observations, the future of chemotherapeutic studies in tuberculosis is not discouraging. At this stage of development the possibilities compare favorably in this particular case with those which offered for the broader subject of chemotherapy when Ehrlich was first able to cure trypanosomatous mice with trypan red. Several substances seem now to be known which are capable of giving a slight advantage to the host in its contest with the parasite. This number must be multiplied by empirical search through known chemical compounds, and each such substance showing a suggestive lead must be subjected to carefully considered chemical manipulation to develop to the full its latent possibilities. Each year of the five that I have been actively engaged in this work has seen some added idea or suggestion of real value, and we may be sure that if in the future faith is expressed in continuous experimentation and confidence is put in evidence by financial support adequate to the size of the task in hand the desired result will be achieved.

REFERENCES.

The following books contain matter of the first importance to anyone interested in the development of the subject of this lecture or related questions:

1. Gesammelte Werke von Robert Koch, Leipzig, 1912.
2. Behring, Gesammelte Abhandlungen, Leipzig, 1893.
3. Paul Ehrlich, Jena, 1914.

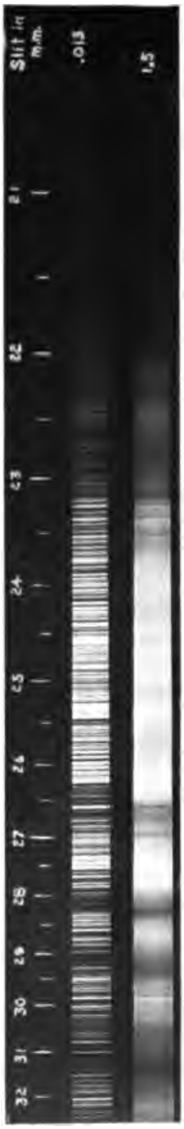

Fig. 1.

(Newcomer: Abiotic action of ultra-violet light.)

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THE ABIOTIC ACTION OF ULTRA-VIOLET LIGHT.

By H. S. NEWCOMER, M.D.

(From the Laboratory of the Henry Phipps Institute of the University of Pennsylvania, Philadelphia.)

Plate 66.

(Received for publication, July 14, 1917.)

INTRODUCTION.

The following data as to the bactericidal action of ultra-violet light on typhoid bacilli were obtained by a method different from that heretofore used and the results give additional evidence toward settling certain disputed phases of the subject.

In 1910[1] and again in 1912[2] Victor Henri and his associates published articles on this subject in which they give evidence to show that the bactericidal effect of ultraviolet light first becomes appreciable at 3000 Ångström units, and increases progressively from there downward toward 2150 Ångström units. The amount of this progressive increase they did not make clear. The evidence tended to show that there was no maximum in this region. The organisms were exposed directly to the ultra-violet light source, so arranged as to limit to a certain extent its spectral range. This limitation was effected by choosing three sources of ultraviolet light such that their intensities in various regions were quite different, and to emphasize further this difference the spectral distribution of their radiation was cut down by the interposition of one of six light-screens. It is difficult from the tables of data to follow them to their conclusions. The upper limit for the action of ultra-violet light they fixed by screening out the lower wave-lengths with glass and determining the amount of screening necessary to prevent the effect.

Browning and Russ[3] state that they prepared plates by making a thin spread of bacteria on glass-supported films of nutrient material. These were exposed in

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[1] Cernovodeanu, P., and Henri, V., *Compt. rend. Acad.*, 1910, cl, 52, 549.

[2] Henri and Henri, *Compt. rend. Acad.*, 1912, clv, 315.

[3] Browning and Russ read a paper on this subject recently before the Royal Society which has not yet appeared in print. Their reading is abstracted, however, in the *Brit. Med. J.*, 1917, i, 656.

As this proof goes to print the paper of Browning and Russ has appeared (Browning, C. H., and Russ, S., *Proc. Roy. Soc. London, Series B*, 1917, xc, the manner of a photographic plate at the back of a quartz spectrograph. The sterilizing action of the light gave a photograph of the active portion of the spectrum. They fixed 2960 Ångström units as the upper limit of effective light.

Lymann[4] has shown that the abiotic effect of ultra-violet light increases rapidly below 2000 Ångström units to become almost instantaneous at 1750. The lower limit of sensitivity has not been fixed. I have shown in a previous paper[5] that typhoid bacilli are slightly sensitive in the x-ray region (1 Ångström unit). There may, however, be one or more minima between 1 and 1750 Ångström units.

Method.

My experiments differ from previous ones in that water is used as a medium for the organisms. Experiments with the x-rays and with chemicals seem to show that nutrient media often protect the organisms from the action of abiotic agents. My experiments further differ from those of Henri and his associates in that the light incident on the organisms is confined in each case by the use of a quartz spectrograph to a very narrow region of the spectrum.

In the following experiments I have used a fresh water suspension of typhoid bacilli. A uniform quantity of the suspension was taken up on a platinum loop and used to fill a quartz capillary by capillary action. The quartz capillary was then fixed in an appropriate graduated rack in the focal plane of a quartz spectrograph and so

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33). They found the cessation of abiotic action to be sharply at 2960 Ångström units for *Staphylococcus aureus*, and slightly higher, at 3000 Ångström units, for *B. typhosus*. An excellent plate for *Staphylococcus aureus* accompanying the article would indicate that the fall in abiotic action becomes perceptible at 2900 Ångström units and comes to zero at 2960 Ångström units. My quantitative data, graphically illustrated in Text-fig. 1, show that this fall to 2960 Ångström units is not so sharp as their plate would lead one to suppose. The probability that long exposures to sunlight have a killing effect would indicate that the curve of the figure approaches the horizontal axis asymptotically, that the curve is concave to the right as shown, rather than convex to the right, as an abrupt fall to zero would imply. My actual numerical data further imply this concavity. Browning and Russ required much longer exposures to kill the organisms than I did. My spectrograph is the same as theirs and my iron spark is probably not brighter than the tungsten arc which they used. The differences in exposure required by us would therefore seem to offer interesting corroborative evidence as to the protective effect of a nutrient medium for bacteria.

[4] Lymann, T., Spectroscopy of the extreme ultra-violet, London, 1914, 103.

[5] Newcomer, H. S., *J. Exp. Med.*, 1917, xxvi, 657.

exposed to a narrow region of the spectrum. After exposure the contents of the capillary were washed out and rinsed by suction in liquid agar and plated, the plates incubated, and counts made. The quartz spectrograph was a Hilger size C, giving a spectrum from 2100 to 8000 Ångström units 19 cm. long. The focal plane of the spectrograph formed an acute angle of about 30° with the light path. For most of the work the condensed iron spark was used as an ultra-violet source. It was placed 10 cm. from the entrance slit of the spectrograph. It was operated by a 10 kilowatt closed circuit transformer using 110 volts alternating current on the primary. The secondary voltage was about 10,000. The condensers had a capacity of 0.05 microfarad. The entrance slit of the spectrograph was opened to 1.5 mm., a width such that the individual lines of the iron spark were spread out into bands of the same width in projection as the quartz capillary. This produced an overlapping of the lines, giving the effect of a continuous spectrum. As a result any setting involved an exposure to a wave-length interval 15 to 40 Ångström units long. Fig. 1 reproduces a photograph of the iron spark spectrum, the upper band being the spectrum with a narrow slit, and the lower, the spectrum as used with a wide slit. The figure gives some information as to the relative intensity of light at different wave-lengths.

My data give the approximate wave-length range of the light falling on the quartz capillary for each setting. These wave-lengths were determined by measurements with a wave-length scale on photographs of the spark spectrum, the rack holding the capillaries being graduated to correspond with the wave-length scale. No attempt is made to give wave-lengths closer than to within 5 Ångström units. The data are computed on a basis of controls having counts of 100 colonies per sq. cm. The actual controls varied from 10 to 800 per sq. cm., usually about 150. When the controls gave more than 1,000 per sq. cm. the suspension contained so many organisms that some of them were protected from the light by being in the shadow of others.

OBSERVATIONS.

Table I gives the data for 10 and 5 minute exposures to the iron spark.

TABLE I.

Exposures to the Iron Spark of 10 and 5 Minutes' Duration.

Wave-length.	10 min. exposures.	5 min. exposures.	Wave-length.	10 min. exposures.	5 min. exposures.
Å. u.			Å. u.		
2070-2105 ~~1990–2005~~	41*	73	2530–2560		0
2145-2170 ~~1995–2010~~	50	62	2540–2570	0	3
2195–2215	8		2550–2580	0	
2205–2225	11		2560–2590	0, 0	½
2235–2255	25		2580–2610	0	0
2240–2260	28	50	2600–2630	0	¼
2250–2270	65		2610–2640	0	0
2270–2290	30		2645–2675	1	9
2280–2300	26		2650–2680	½	1
2290–2310	2,22	51	2655–2685	1½, 1½	3½
2325–2350	2½	4	2680–2715	0, ½	3, 3
2330–2355	1	14	2700–2735	0	1
2335–2360	2½	3	2760–2795	0	
2350–2375	3½	11	2780–2815	0	9,10
2365–2390	⅛	1½	2785–2825	1	
2385–2410	0, ½	0, 1½, 3	2790–2830	2	5
2405–2430	$\frac{1}{10}$	1¼	2795–2835	1½	4½
2435–2460	0	2	2845–2885	7	
2455–2480	1	2½	2850–2890		16, 17, 20
2485–2510	0, 0	0, 1, 1	2855–2895	3, 2½	5, 7½, 7½
2495–2525	0	1, 1, 2	2875–2915	7	
2500–2530	0	0	2945–2985	40, 45, 50	
2525–2555	0	¼			

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* In the tables the data represent typhoid organisms per hundred remaining alive after the given exposure.

It is to be noted that the abiotic effect is low from 2100 to 2300. This corresponds to a portion of the iron spark spectrum of relatively weak intensity. In order to determine the nature of the effect in this region exposures were made to the copper and zinc spark, sources with lines of about equal intensity in this and higher regions of the spectrum. Table II gives the results of these exposures and shows that the effect is about the same in this region as elsewhere.

TABLE II.

Exposures to the Copper and Zinc Sparks.

Copper spark.		Zinc spark.		
Wave-length.	10 min. exposures.	Wave-length.	10 min. exposures.	5 min. exposures
Å. u.		Å. u.		
2130–2140	57, 22	2070 ~~1990~~–2105	1	14
2180–2195	30, 23	2130–2145	5	21
2205–2225	30	2190–2210	37	
2235–2250	32	2250–2270	37	61
2265–2290	47	2490–2530*		1
2295–2320	79, 81	2545–2575*		0
2360–2385	24	2800–2840*	2	1½
2590–2620	47, 63			
2750–2785	49			

* Very strong lines.

The relative intensity of the light in the various portions of the spectrum could only be measured photographically, and comparisons were further made difficult by the fact that the plate gradually decreased in sensitivity in the far ultra-violet. Between 2100 and 2800 the exposures of Table I showing a slight relative decrease in abiotic effect correspond well with weak regions in the spectrum. Above 2800 the abiotic activity of the light begins gradually to fall off. This can be seen well in Table I and in Table III for 2 minute exposures.

TABLE III.

Exposures to the Iron Spark of 2 Minutes' Duration.

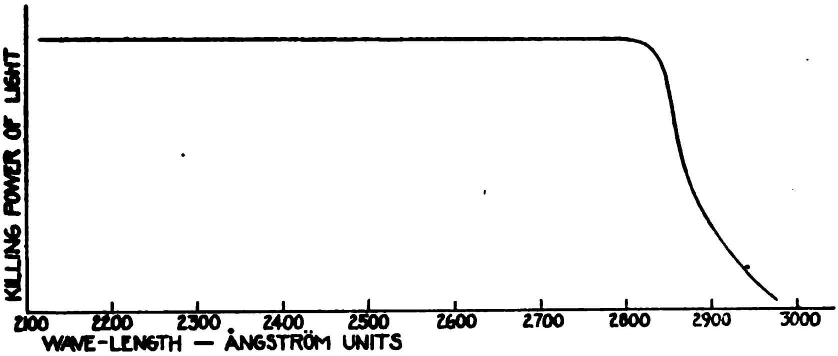
Wave-length.	2 min. exposure.	Wave-length.	2 min. exposure.
Å. u.		Å. u.	
2365–2390	13, 12, 13	2580–2610	1, 0, 1, 0
2385–2410	16, 20	2680–2715	22, 20, 21
2435–2460	13, 12½, 12	2850–2890	45, 52, 45
2530–2560	4, 2, 2, 1½, 1		

From Table III the decrease would appear to begin at 2700, but at this point the iron spark spectrum is rather weak. At 2750 the spectrum is very strong and here exposures corresponded with those made at 2600, also a relatively strong place in the spectrum. The iron spark spectrum is slightly weaker below 2500 than above that point. Below 2320 it is very weak. Above 2780 it weakens perceptibly. About 2870 corresponds to a region of the spectrum equal in intensity to the 2700 region. At 2870 the tables show a decrease in abiotic activity. This decrease when corrected for the weakness of the spectrum amounts to a fall of one-half. The last appreciable abiotic effect occurs somewhere between the moderately strong 2950 and 2990 lines. In this region the intensity is about the same as at 2700 and 2870. At 2945 to 2985 exposures for 10 minutes averaged 55 per cent killed, for 20 minutes 81 per cent killed. An average of eight exposures at 2990 to 3030 for 20 minutes gave no mortality. These exposures at 2945 to 2985 and 2990 to 3030 were controlled for evaporation and for scattered light. Longer exposures were impracticable because of the increasing influence of both these factors, particularly the former. Complete evaporation of the contents of the capillary occurring in about 40 minutes will completely or almost completely kill the typhoid organisms.

In order to limit further the upper end of the abiotic spectrum exposures were made directly before the iron spark but behind a piece of optical glass 3 mm. thick. The distance from the spark was 4 cm., the increase in energy due to lessened distances alone amounting to 256 times. Besides this, the whole area of the spark was effective rather than a portion corresponding to the slit area. This introduced another factor so that there was an increase of about one thousandfold. The glass transmitted no light below 3100; above 3300 it was almost transparent. These exposures of 5 and 10 minutes' length had no effect on the typhoid organism. The terrestrial sun's spectrum ends somewhere near 2970. Exposures to sunlight of 20 minutes' duration produced no effect.

I, therefore, conclude that the killing power of ultra-violet light begins to decrease at about 2800, at first very gradually, reaches one-half of its value at about 2870, one-tenth of its value at 2950, and less than one one-hundredth at 2990. Text-fig. 1 gives a sketch of the probable form of the abiotic curve. As far as I can judge equal intensities produced equal effects in the region 2100 to 2800. If there is a maximum in this region it is at the most only slight and would be in the neighborhood of 2600.

The relative effect of much shorter exposures is shown in Table IV. These exposures give at the same time further data for determining the relation between quantity of energy and per cent of organisms killed. This relation, most likely an integral of the probability law, must be known in order to derive from the tables the form of the abiotic energy curve of Text-fig. 1.



Text-Fig. 1. Graph representing the approximate amount of abiotic energy in ultra-violet light as referred to the typhoid bacillus.

TABLE IV.

Short Exposures to the Iron Spark

Time.	Wave-length.	
	2385-2410 A. u.	2580-2610 Å. u.
sec.		
60	14, 16, 14, 12	1, 5, 6
50		2
40		3, 3, 2
30	36, 24, 12	5, 4, 5
20		11, 7, 8, 4, 10
15	72, 50, 42	
10		12, 25, 11, 12, 17, 40

The Wratten and Wainwright panchromatic plate requires an exposure of about $\frac{1}{4}$ second under these conditions. At 2600 a 95 per cent sterilization of a *Bacillus typhosus* suspension is secured in about 200 times this length of time. The typhoid organism therefore compares very well with the slow silver papers in degree but not in range of sensitivity.

In similar but less extensive experiments I have found *Staphylococcus aureus* to behave exactly like *Bacillus typhosus*.

CONCLUSIONS.

Typhoid bacilli are about one two-hundredth as sensitive to ultraviolet light of wave-lengths 2100 to 2800 Ångström units as is the photographic plate. This sensitivity then falls off, decreasing rapidly to almost zero sensitivity at about 2970, the beginning of the sun's spectrum.

I wish to thank Dr. Paul Lewis for suggestions and advice in the arrangement of the experiments.

EXPLANATION OF PLATE 66.

FIG. 1. The iron spark spectrum between 2100 and 3200 Ångström units. The upper band is the spectrum with a narrow slit, the lower band, the spectrum with a wide slit as for bacterial exposures. Below 2320 Ångström units the faintness of the spectrum is real. Below 2200 the increasing faintness is due to the plate.

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BACTERICIDAL FLUORESCENCE EXCITED BY X-RAYS.

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(Received for publication, June 5, 1917.)

INTRODUCTION.

The purpose of this article is to report an experiment which, coupled with underlying theoretical considerations, points to a mechanism by which the x-rays may be made to have a strong bactericidal effect.

It was suggested to me over a year ago that the fluorescence of dyes be studied from the point of view of determining whether there might be a relationship between this property and bactericidal action. The photodynamic effect of various dyes had previously been investigated, especially by Jodlbauer and von Tappeiner.[1] Dilute solutions of the dyes containing suspensions of various organisms were subjected to strong diffuse daylight and the results compared with controls kept in the dark. In general these experiments have given contradictory and unsatisfactory results and the influence of fluorescence as a factor was open to doubt.

Various forms of radiation have been and are being studied from the point of view of abiotic effect. Considering the spectrum as a whole from the very short or x-rays up through the ultra-violet and visible to the long infra-red and heat waves there are only two regions in which the rays have any considerable abiotic effect; namely, in the ultra-violet and infra-red. Most work has shown that the other spectral regions have very little bactericidal effect. Of these two regions the infra-red is probably not of practical value for our purposes, heat being harmful to all protoplasm. Of all radiation the ultra-violet is by far the most bactericidal and the least penetrative. Unfortunately, to be of practical value abiotic radiation must be capable of penetrating tissue. To alter the penetrative qualities of radiation is hopeless on the face of it.

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[1] Jodlbauer, A., and von Tappeiner, H., *Münch. med. Woch.*, 1904, li, 1096. Mettler, E., *Arch. Hyg.*, 1905, liii, 79.

From the point of view of utilization of radiant energy as a therapeutic bactericidal agent the problem therefore reduces itself to seeking to secure a transformation of penetrative energy into some form of energy having abiotic properties. Heretofore the attack has been along chemical lines. Transformation of energy is essentially a physical phenomenon and there is already at hand a very definite mechanism by which a transformation of this character may be produced; namely fluorescence. In order that this mechanism may be here applied, obviously two conditions must hold. In the first place, the fluorescent light, the light emitted by the substance when excited, should of itself have abiotic properties. In the second place, the exciting light, the light causing the fluorescence, must have considerable penetrative property. If these conditions hold, then abiotic light can be produced at any point to which the substance can be brought and the imposition of further physiological conditions would give a practical solution of the problem.

HISTORICAL.

The abiotic properties of radiant energy are best shown by ultra-violet light. The known ultra-violet extends from about 600 to 4000 Ångström units (0.06μ to 0.4μ). Its abiotic properties have been given considerable attention, perhaps most precisely by Victor Henri and his associates.[2] He investigated the effect on microorganisms from about 3600 down to about 2100 Ångström units, using a few filter screens to obtain an idea as to the relative effect of different portions of the region. He concluded that the abiotic effect first became appreciable somewhere between 2800 and 3000 Ångström units and increased progressively with decrease in wave-length. Lyman[3] has shown that the effect increases markedly below 2000, being almost instantaneous somewhere below 1750.

We have repeated the experiments of Henri using a more precise method and have come to the same general conclusions, placing the upper limit at about 2800 Ångström units and finding an approximately constant effect from there to 2100. In this region the typhoid bacillus is about one two-hundredth as sensitive as the photographic plate. Below 2000 Ångström units all materials become rapidly increasingly opaque. 2 cm. of water transmits at 2000, 86 per cent; at 1930, 75 per cent; at 1860, 30 per cent; and at 1729 Ångström units, 0.5 mm. of water is opaque.[4] It is therefore probably safe to set the figures 1800 to 2800 as defining the useful limits of the abiotic spectrum.

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[2] Cernovodeanu, P., and Henri, V., *Compt. rend. Acad.*, 1910, cl, 52, 549. Henri and Henri, *ibid.*, 1912, clv, 315.

[3] Lyman, T., Spectroscopy of the extreme ultraviolet, London and New York, 1914, 103.

While the employment of red light as a penetrating radiation offers certain ulterior advantages, physical considerations discourage the prospect of producing ultra-violet fluorescence by this means. Fluorescence is almost invariably of longer wave-length than its excitant. A good example of this is the dye fluorescein. Dilute solutions of this fluoresce a bright green in daylight but by lamplight lose the property, lamplight containing plenty of green rays but no shorter blue waves. This same general law of fluorescence renders it probable that the x-ray should produce ultra-violet fluorescence, and in fact oftener than it does visible fluorescence. The latter type of x-ray fluorescence has long been known; the discovery of x-rays was due to this property.

The fluorescence problem thus resolves itself into the discovery or manufacture of substances which shall have desirable biological properties and at the same time emit light of wave-length less than 2800 Ångström units when subjected to x-radiation. The problem is therefore one which is rational and which at the same time offers far reaching possibilities.

It is well at this point to give an outline of the work as to the effect of x-rays alone on microorganisms. The literature on this subject seems to have stopped in 1906 with the publication by Russ[5] of a long article which also summarizes the results of previous workers. They all, with one exception, had obtained negative results, even with very long exposures to the x-rays. A great many pathogenic organisms were tried and in the presence of various culture media. Rieder[6] in 1898, using an apparatus incompletely described, was able to almost sterilize agar and gelatin plates of cholera, diphtheria, typhoid, and colon organisms, with exposure for about 1 hour. Bouillon cultures were not so clearly affected. These results are in disagreement with those of everyone else including ourselves. A study of Rieder's article, however, does not reveal any probable cause for the discrepancy. Russ performed four types of experiments. He exposed the media to determine whether exposure rendered them unfit for culture purposes. He exposed organisms under the objective of the microscope in order to observe the effect upon their motility and clumping. He exposed the organisms in the various culture media and he inoculated exposed organisms into animals. All his experiments were entirely negative except for increased motility under the microscope in some cases. His exposures were from ½ to 2 hours, using a fairly powerful apparatus and soft, medium, and hard tubes. Our experiments incidentally check the work of Russ.

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[4] Lyman,[3] p. 60.

[5] Russ, V. K., *Arch. Hyg.*, 1906, lvi, 341.

[6] Rieder, H., *Münch. med. Woch.*, 1898, xlv, 101, 773.

It was shown in 1905 by Schuhknecht[7] that the fluorescence in fluorite excited by x-rays extends from 2310 to 3900 Ångström units with a maximum at 2840. This mineral, therefore, should be suitable to use in experiments designed to demonstrate the essential correctness of the above considerations.

We have therefore undertaken the experiments reported in the following pages. The results embody an answer to the following questions. (1) Have the x-rays any bactericidal value and if so under what conditions is it demonstrable? (2) Can the x-rays be shown to have an increased bactericidal value when the bacteria are exposed to them in contact with a substance (fluorite) of such chemical and physical constitution that the x-rays excite fluorescence in it? (3) The second question being answered in the affirmative, is the increased activity due to chemical products contributed to the medium in which the bacteria are suspended, or is it due to physical agencies, presumably rays of light in the ultra-violet region of the spectrum?

The general conditions governing the experiments were as follows. The x-ray apparatus[8] consists of a coarse focus Coolidge tube operated by a Snook interrupterless transformer. The tube was operated on a 4 milliampere current backed up by a voltage equivalent to a 9 inch spark-gap. A 1 mm. aluminum filter plus black paper was used and the objects were placed at a distance of 7 inches from the anticathode. The doses were in multiples of 5 minutes, a 5 minute pause occurring between each 5 minute exposure. Fresh 18 hour agar slant cultures of *Bacillus typhosus* were used, a suspension of the organisms in some medium, usually distilled water, being made. One of these suspensions stays nearly constant in count throughout the day. Each figure in the tables gives the average bacterial count per square centimeter for an agar plate made from the suspension in question.

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[7] Schuhknecht, P., *Ann. Physik.*, 1905, xvii, 717.

[8] The x-ray apparatus was kindly placed at my disposal by Dr. David R. Bowen of the Pennsylvania Hospital.

In earlier experiments with small capillary tubes of glass as containers, certain specimens of glass gave much lower bacterial counts than the average. As glass of certain kinds is known to fluoresce under the x-rays, in order to avoid this effect paraffin was chosen as a sufficiently inert substance from which to construct containers. In order to demonstrate its inertness holes of two sizes were made, one $\frac{1}{2}$ inch in diameter and the other $\frac{1}{10}$ inch in diameter. These two have a considerably different ratio of wall to volume and figures obtained with them should therefore serve to demonstrate any influence of the wall. Experiments showed no difference for exposures in the two sizes of holes (Tables I and II). This at the same time serves to eliminate the size of the hole as a factor in determining the outcome of the experiment. In order to prevent evaporation from the holes they were sealed with thin sheets of paraffin.

Action of X-Rays Alone.

Table I gives the results of the exposure of water and normal salt solution suspensions of the bacteria to the x-rays.

TABLE I.

25 Minute Exposures of Salt Solution and Water Suspensions of Bacillus typhosus.

Medium.	Exposed.	Controls.	
		Before.	After (2 hrs.).
Salt solution, small hole...........	40, 43	180, 200	
Water, large hole..................	17, 12, 17, 17	55, 54, 60	60, 70, 70
" small "	15, 18, 17	61, 70	74
" " "	39, 38, 41	140, 135	130
" " "	44, 43	140, 145	

The figures are bacterial counts of a suspension of *B. typhosus* in water and normal salt solution exposed to the x-rays, the containers being $\frac{1}{2}$ and $\frac{1}{10}$ inch holes in paraffin blocks.

In my hands there has been uniformly a considerable reduction in the bacterial count of these suspensions. As the typhoid organism was supposed to be unaffected by the x-rays, experiments were made to determine the cause of this discrepancy. Water had never been used before as a medium. Usually the observations were made by exposing agar or gelatin plates. Even Rieder did not demonstrate an effect with bouillon as a medium. An agar plate does not make a good experiment. Presumably each individual organism after fixation in the media has already started to multiply before the necessary procedures incident to exposure are completed. As a result an agent which will kill 30 per cent of the organisms will presumably still leave in each potential colony at least one live organism and the full number of colonies will be produced. At any rate the plate experiments were tried using 25 minute exposures and protecting half the plate with ½ inch of lead. The experiment was entirely negative whether the plate was incubated 1 hour before radiating or exposed immediately; that is, in about 15 minutes.

Table II shows that bouillon may have a protecting effect.

TABLE II.

25 Minute Exposures in Water and Bouillon of Bacillus typhosus.

Medium.	Exposed.	Controls.	
		Before.	After (2 hrs.).
Bouillon culture 4½ hrs. old	900, 1,150, 1,300	750, 700	1,500, 1,700, 2,000
" suspension, large hole	50, 45, 45, 47	80, 76, 80	85, 87, 92
" " small "	36, 25, 36	75, 60	70, 82
Water, large hole	17, 12, 17, 17	55, 54, 60	60, 70, 70
" small "	15, 18, 17	61, 70	74

The figures are bacterial counts of typhoid bacilli grown in bouillon or suspended in bouillon and in water, exposure being made to the x-rays in containers consisting of ½ and $\frac{1}{16}$ inch holes in paraffin blocks.

A 4 hour bouillon culture exposed 25 minutes merely had its growth during the time of exposure partially inhibited. On the contrary, a bouillon suspension made just before exposure was reduced almost one-half in count. Water suspensions under similar conditions had their bacterial counts decreased to from one-third to one-fourth.

While these experiments are not conclusive as fixing the exact action of the x-rays alone, they nevertheless demonstrate the relative constancy of an effect much less potent than that presently to be described.

It should be noted in experiments of this sort that if the number of organisms dying in successive short intervals of time during which a destructive agency is acting be plotted, the points constitute a locus which tends to have the form of a probability curve, a curve having somewhat the shape of the profile of a wide flanged bell. This is the ordinary probability relationship familiar to everyone. The organisms die rapidly during part of the time causing a heaping up of the number of deaths in a short interval. In this interval of high mortality the total number killed increases very rapidly. This period is preceded and followed by intervals in which the additions to the figures for the total dead are less rapid. If the figures giving the total dead up to any time be plotted they form a locus having a different form from the above locus for rate of death. This new locus approximates a curve whose slope (tangent of the gradient angle) at any point is given by the height of a corresponding point on the probability curve, in other words by the death rate.[9] It is a curve, therefore, which starts with a low slope, gradually increasing to a maximum of steepness at the point of greatest mortality, then rising less and less rapidly to approach asymptotically a horizontal representing the total number of organisms subject to death. The total number dead increases slowly at first becoming rapidly larger as the point of 50 per cent sterilization is approached. From here on the number of dead increases less and less rapidly until finally all are dead.

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[9] The probability curve has a form given by the equation $y=e^{-x^2}$. For a mathematical discussion of the subject see the article on "Probability" in the Encyclopædia Britannica, 9th edition. In this article Fig. 1 outlines the shape of the curve. The area of each quadrilateral would represent the number of deaths occurring in an interval of time represented by the length of its short side. The total number of deaths caused by a dose acting up to any instant of time would be represented by the sum of all the preceding quadrilaterals; that is, by the area under the curve up to that point. The values of the second half of this integral from the mid-point of the curve on, are given in the table under paragraph 9. Plotted, they give the second half of the total mortality curve, the first half of the curve being the symmetrical extension backwards of this locus. It is on a curve of this form that the figures in my tables tend to lie if they are plotted against the length of dose. The Encyclopædia Britannica, 11th edition, under "Probability" gives in Fig. 10 the form of the probability curve and in paragraph 99 the table of values of its integral.

Slight variations in the conditions of the experiment may shift this period of rapid sterilization a little one way or the other, thus producing excessive variations in the results of experiments ending within the period. Conversely large doses will require considerable increments to produce additional deaths. The increase in energy required to kill the last 10 per cent is greater than that required to kill the middle 50 per cent.

Influence of Fluorite.

The first experiments with fluorite were made with the native powder. They proved unsatisfactory on account of the controls, the powder alone killing a large percentage of the organisms. This was probably an agglutinating effect produced by shaking with the very fine microscopic crystals. Larger chipped crystals were tried but floating crystals here disturbed the uniformity of size of the drop on the plating loop. A large greenish crystal of fluorite weighing 122 gm. was then obtained from the collection of the Drexel Institute and into this a hole 1 cm. deep was drilled with a No. 42 drill (about $\frac{1}{10}$ inch). This hole when thoroughly washed out has smooth glass-like walls and organisms suspended in water placed in it for 2 hours were uninfluenced as shown by Table III.

TABLE III.

Influence of Fluorite Container Alone.

Control before	340, 320, 330
Fluorite hole, 2 hrs.	360, 340, 320
Paraffin " 2 "	320, 330, 360
Control after	360, 310, 340

Water suspensions of *B. typhosus* placed in $\frac{1}{10}$ inch holes in fluorite and paraffin and left there for 2 hours. The suspensions were then syringed out and plated.

Some difficulty was experienced in obtaining uniform loops of material for plating under the varying conditions. When plating from ordinary test-tubes the surface of the liquid is sufficiently large so that its surface tension does not influence irregularly that of the loop. With small holes or small drops the varying surface tension influences considerably the size of the drop on the loop. By placing equal quantities of material on cover-slips a fairly uniform loopful could be obtained. Suspensions placed in small holes in fluorite or paraffin were syringed out well and placed on cover-slips. The angle and velocity of the loop in leaving the drop on the cover-slip were kept about the same and the size of the drop was observed as satisfactory before plating. Control experiments were made with No. 42 holes in paraffin blocks. Table IV gives the results of exposures with the Drexel crystal.

TABLE IV.

Bactericidal Effect of Fluorite Fluorescence.

Exposure.	Fluorite.	Paraffin.	Control, not exposed.
min.			
15	2, 1, 2	80, 75, 75, 75	105, 110, 115, 111, 117
20	2, 3, 4,	70, 100, 100	160, 170
20	8, 7	140, 140	170, 170, 190

Exposures to the x-rays of water suspensions of *B. typhosus* in $\frac{1}{16}$ inch holes in fluorite and in paraffin.

One of the 20 minute exposures giving a 95 per cent mortality (7, 8 colonies per sq. cm.) is relatively the weakest bactericidal effect obtained with this crystal in any of the experiments. The corresponding controls in paraffin showed a mortality of from 22 to 45 per cent, depending upon the length of exposure and upon ordinary experimental variations. As indicated above the 95 to 98½ per cent mortality found here means relatively more than the 50 per cent mortality of the x-rayed controls.

Nature of the Effect.

In order to limit the possibility of a chemical effect induced by the x-rays the procedure was adopted of placing the organisms in small quartz capillaries and sealing with a tiny bit of paraffin at each end. This operation is entirely without effect ot itself. The quartz is transparent to ultra-violet light and the arrangement limits the possible interpretations of the experiment.

The results of these exposures are given in Table V. They paralleled those made without the quartz protection. The difference between the quartz and paraffin exposures may be accidental or it may be due to some effect of the quartz itself. It is not impossible that the quartz may be slightly fluorescent under the x-rays.

TABLE V.

The Bactericidal Effect of Fluorite Fluorescence Is Not Chemical.

Exposures.				Controls.		
Exposure.	Fluorite and quartz.	Quartz.	Paraffin.	Stock.	Fluorite 2 hrs.	Quartz 2 hrs.
min.						
15	15, 14	60, 45, 40	54, 52, 48	140, 145, 130		130, 140, 130, 160
25	0, 0	40, 34	40, 43	180, 200	170, 180	
25	1, 1, 1	15, 19, 16, 17, 21, 19, 16, 18	39, 38, 41, 61	140, 135	120, 240	120, 160

Exposures to x-rays of water suspensions of *B. typhosus* enclosed in quartz tubes and placed in a hole in the fluorite crystal.

Table VI gives the results of 15 minute exposures of other crystals, with protection.

These crystals are all average specimens as seen in mineralogy collections, not being very perfect in form. They included clear white, green, and purple specimens. All were about equally active except a rather deeply colored light green crystal from Deming, New Mexico. Their visible fluorescence under the x-rays varied, being green, blue, and violet. Their weights ranged from 14 to 122 gm.

Table VII gives the results of an exposure of certain of these crystals, the suspensions being placed in the holes without quartz protection.

TABLE VI.

Variations in Crystals, Quartz Protection.

	Exposures.								Controls.	
Origin.	Fluorite crystals.						Quartz.	Paraffin.	Stock.	Quartz.
	Drexel.	Wear, England.	Deming, N. M.	Freiberg, Saxony.	Freiberg, Saxony.	Macomb, N. Y.				
Weight in gm.	122	97	37	14	52	46				
Color.	Green.	Bluish.	Green.	White.	Purple.	Slightly green.				
Fluorescence.	Green.	Blue.	Green.	Violet.	Violet.	Green.				
Bacterial count.	15, 14	16, 15	28, 35	4, 5	8, 7	8	60, 45, 40	54, 52, 48	140 145 130	130, 140, 130, 160

Exposures to x-rays of water suspensions of *B. typhosus* in $\frac{1}{16}$ inch holes in various crystals, the suspensions being protected by quartz.

TABLE VII.

Variations in Crystals, without Quartz Protection.

Exposure.	Crystals.					Controls.
	Drexel.	Freiberg (white).	Macomb, N. Y.	Deming, N. M.	Paraffin.	Stock.
15 min.....	2, 1, 2	1, 1, 1	2, 2, 2	10, 10, 8	80, 85, 75, 75	105, 110, 115, 111, 117
None......	180, 180	140, 180	150, 160, 150	140, 160		180, 160

Exposures to the x-rays of water suspensions of *B. typhosus* in holes in the various crystals, together with 2 hour controls, without exposure.

The rather high mortality in fluorite shown here is probably not significant of anything but ordinary experimental variations.

There seems to be no insurmountable obstacle to the development of substances having this property of fluorite and at the same time being biologically more appropriate. It is hoped that a new and productive field of experimental therapy has been opened up.

CONCLUSIONS.

X-ray fluorescence has been pointed out as a mechanism offering exceptional possibilities in the development of physicochemical therapy.

Experiments are given which demonstrate that under these conditions the x-rays may have a strong bactericidal effect.

The x-rays alone have a partial bactericidal action on water suspensions of typhoid bacilli.

I take pleasure in expressing my indebtedness to Dr. Paul A. Lewis for his advice in the development of these conceptions and the carrying out of the experiments.

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NOTE ON A WET CONDENSER SUITABLE FOR CONTINUOUS HIGH POTENTIAL SERVICE

In certain investigations necessitating long continuous production of a fat spark by means of a closed circuit transformer (1 K.W., 110 v. primary, 11,000 v. secondary) it was found that the glass plate condensers usually provided for this purpose repeatedly broke down owing to the heating under continuous performance. It occurred to us to substitute the ordinary glass with some glass having greater heat-resisting properties.

One liter, tall form, lipless "Pyrex" beakers were accordingly covered with tinfoil as carefully as possible, both on the inner and outer surfaces. These were then mounted by placing the edge into a groove in a board and sealing in with rosin. Condensers of this kind were tedious to make, and proved quite a problem to mount securely. The labor involved in producing a set of the required capacity stopped work in this direction.

The final form of condenser which has proved very serviceable for the work in hand was that in which the "Pyrex" glass beakers mentioned above constituted the dialectric, and a nearly saturated solution of common salt constituted the conductor plates. The beakers were filled to within 2.5 cm. of the rim with the solution, and were immersed to a similar depth into the solution contained in an earthen vessel, a 3 gallon crock. The beakers measure 9 cm. in diameter, 19 cm. high, 16.5 cm. effective height, thickness, about 1.2 mm. The twenty beakers used were selected from a stock of about 100 in order to avoid flaws, particularly bubbles. The stock was a little old and therefore probably not as good in evenness of surface and homogeneity of material as that now being manufactured. It was not possible to avoid such defects entirely, but it is interesting to note that no beaker has proved defective after very long and severe use.

The place subjected to greatest danger of puncture and that which allows greatest leakage is where the exposed surfaces of the solution inside and out come in contact with the surface of the beakers. This defect can be reduced considerably by filling the beakers with the salt solution to a slightly different level from that of their containers. Care should be taken not to wet the portion of the beaker that is not immersed. To eliminate sparking quite completely, however, the surfaces of the solution inside the beakers and that surrounding the beakers were covered with a layer of oil 5 cm. deep. For this purpose a 300-degree mineral seal oil was used. This oil, as Mr. C. E. Skinner kindly informed us, has very good dialectric properties—as good as can be expected from an oil not free from water. Whether this layer of oil eliminated sparking at the sacrifice of some capacity we have not determined.

The capacity of these condensers was estimated by the method of divided discharge and by the method of mixtures. The capacity of each of the five jars containing four beakers each was: .0088 M.F., .0091 M.F., .0093 M.F., .010 M.F., .0088 M.F. respectively. The mean of these capacities is .0092 M.F. A similar estimation of the capacity of two such beakers covered with tinfoil indicated that their combined capacity was very appreciably less than two beakers of the wet condenser. This is probably due to the unevenness of the surface and the difficulty of making contact between the glass and the tinfoil.

A comparison was made between the wet condenser as above described in which beakers of Jena glass and of "Pyrex" glass were used. The dimensions of these beakers were approximately the same. Assuming that the average thickness of the "Pyrex" beaker is equal to that of the Jena and assuming the dielectric constant of Jena glass to be 6.5, that of "Pyrex" glass must be about 4.8.

A comparison was also made as to the influence of the character of the conducting medium. Beaker condensers were set up using mercury, concentrated salt solution and distilled water (iron still), respectively. The capacities of the latter two were equal within the limits of error of measurements, while the capacity when using mercury was 10 per cent. higher than when using the salt solution. The slight superiority of mercury at low constant potential seems to be very greatly enhanced at the high and discontinuous potentials employed to produce the spark, where, judging by the fatness of the spark, the capacity of the condenser with mercury is three or four times as great as that of the condenser with salt solution.

This wet condenser has given perfect satisfaction under severe use for many months. Its cost is approximately the same as the glass plate condenser and considerably less than similar condensers covered with tinfoil.

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ON THE ELECTROLYTIC DIAZOTATION OF AN ALIPHATIC COMPOUND.

BY ROBERT B. KRAUSS.

Received April 21, 1917.

Introduction.

In the course of the preparation of a large number of new azo dyes and our study of their relation to the chemotherapy of tuberculosis during recent years, it became desirable to synthesize compounds containing aliphatic side chains linked to benzol and naphthalene rings through the N-N group. Since the literature of the diazo reaction held but little prospect of a method of general application along strictly chemical lines. our attention was turned to the development of the electrolytic method suggested for aromatic derivatives by Löb.[1]

Historical.

The diazo reaction was discovered by Peter Griess[2] in 1862 and carefully studied by him. On adding a concentrated potash solution to diazo benzene chloride, he obtained potassium diazotate. In 1894 Schraube and Schmidt[3] observed that diazo benzene chloride and strong caustic heated together to 130–140° gave a salt isomeric with Griess' salt, an isodiazotate. It did not have the property of forming azo colors directly with an alkaline phenol, but regained this property on making it acid first and then adding it to an alkaline phenol. In the next thirty years countless attempts were made to diazotize aliphatic amino compounds and isolate or couple them. It was found that the amino group was replaced by a hydroxy group and that the intermediate diazo compound was not stable.

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[1] *Z. Electrochem.*, 10, 237 (1904).

[2] *Ann.*, 121, 257 (1862); 137, 39 (1866).

[3] *Ber.*, 27, 514 (1894).

About 1888 Curtius[1] on replacing the reactive hydrogen atom of the carboxyl group of glycocoll by the ethyl or methyl group, was able to obtain, by treatment with nitrous acid, diazo acetic esters. It was also found that compounds having NH_2 in the alpha position to CO or CN formed similar diazo derivatives, which were however less stable than the esters.

Pechman[2] later found that acylated nitrosamines when treated with sodium hydroxide decomposed into diazomethane, also that alkylamine in the form of its urethane, would react with nitrous acid to form a nitrosamine which could in turn be hydrolyzed by alkali to diazomethane.

Hantzsch and Lehman[3] investigated this reaction and concluded that methyl azotate, the hydrate of the diazo compound, was formed but broke down into its anhydride.

In short, none of these methods produce aliphatic diazonium salts analogous to the reactive aromatic diazonium salts but instead form non-reactive diazo anhydrides and their derivatives.

Löb discovered that azo dyestuffs could be made by electrolysis. To obtain them he dissolved molecular quantities of the amine, sodium nitrite and the second component in water and passed a current through the solution. The reagents were placed in an anode compartment which was separated from the cathode by a porous cell. The usefulness of this method is restricted by the fact that only phenols can be used as second components. Löb insisted that the second component must be present in the solution so that the diazo compound as fast as formed should be coupled and removed from the zone of reaction. The remarkable feature of this method is that no artificial cooling is necessary. In the strictly chemical diazotations, temperatures between 0° and 10° must be maintained.

Method.—A consideration of the various points involved in the problem led us to lay down the following working conditions as those which might probably be successful:

To fix the diazo salt at the instant of its formation, before it passed into its anhydride.

To maintain a low temperature to permit of its formation.

To diazotize electrically avoiding the use of acid.

On account of accessibility, the substance chosen for our experiments was glutamic acid.

Preparation of Glutamic Acid.—Of the amino acids glutamic is the most readily isolated in quantity since its hydrochloride is insoluble in concentrated hydrochloric acid. When prepared by the hydrolysis of protein the only difficulty lies in the initial crystallization of the hydrochloride. The viscosity of the solution due to the presence of other amino acids in quantity seems to greatly retard the formation of crystals, which at best are very small and hard to filter. The following procedure gives satisfactory results with yields of about 10%:

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[1] *J. prakt. Chem.*, 38, 407 (1888).

[2] *Ber.*, 28, 855 (1895).

[3] *Ibid.*, 35, 901 (1902).

The most economical raw material is casein. 1500 g. of commercial casein are added to 4.5 liters of concentrated hydrochloric acid contained in an 8-liter round-bottom flask. The protein is then hydrolyzed by boiling under a reflux condenser. It is convenient to boil for 24 hours, but less time is probably sufficient. The biuret test may be applied to determine complete hydrolysis.

When cool the solution is filtered to remove fat and humin and concentrated to 2.4 liters. After standing in an ice box for at least 24 hours, the mass should be filtered on a Büchner funnel. After washing with a little absolute alcohol the glutamic acid hydrochloride is dissolved in just sufficient hot water and filtered. The solution is saturated with hydrochloric acid and set in the ice box to crystallize. The hydrochloride is again filtered, washed and dissolved.

The solution, somewhat diluted, is boiled with animal charcoal and after concentrating, saturated with hydrochloric acid. Filter, wash with absolute alcohol and dry. The glutamic acid hydrochloride should be pure white.

Glutamic acid is prepared by neutralizing with caustic soda. 183 g. glutamic acid hydrochloride are dissolved in 350 cc. hot water. 40 g. caustic or proportionally more, if it is not anhydrous, are dissolved in 50 cc. water. The alkali is then added very slowly to the hot glutamic solution, all the time stirring vigorously. The precipitate should be crystalline and settle rapidly. It is filtered off when cold and washed with a little water and then with alcohol. Dry at 110°. The glutamic acid should be white and free from chloride.

Apparatus.—A small stoneware crock was used as the cathode chamber. This was placed inside a larger one with an insulation of cotton waste between. A 300 cc. porous cup placed inside the cathode chamber formed the anode chamber.

Methyl alcohol chilled by passing through a copper coil submerged in an ice and salt mixture is pumped by an electrically driven gear pump through a glass coil in the anode in series with a copper coil in the cathode chamber, and then returned to the cooler.

The anode consists of a circular platinum gauze electrode 3 cm. in diameter rotated at about 200 r. p. m. by motor.

The cathode is the copper cooling coil in the cathode chamber.

During the experiment the temperature has been kept between 0° and —2° for the most part. It has occasionally fallen to —4°.

Current.—The direct current was obtained from a motor generator set and then suitably regulated by resistance on a special switchboard making it possible to obtain any current from 0.01 to 10 amperes at convenient voltage steps. During these experiments the current was maintained at 3.5 amperes and 7 volts.

Electrolytes.—The anode electrolyte used was glutamic acid in an excess of caustic soda solution with the addition of sodium nitrite, the quantities of each being varied as shown below:

	Molecular.	2.	3.	4.	5.	
Glutamic acid	45	45	45	30	30	
Sodium nitrite	21	25	25	30	30	(In grams)
Sodium hydroxide	36	50	80	34	75	

The cathode electrolyte was 30% caustic soda solution.

Result of Electrolysis.—When the current is passed through any of the foregoing mixtures under the stated conditions the solution gradually acquires an orange-yellow color. After numerous trials it was found that a run of about four hours with electrolyte mixture No. 4 gave a maximum of orange color in the anode chamber. Electrolyzing for an indefinite additional period caused no change in color.

Separation.—The anode solution is then removed from the apparatus, filtered and treated in a 3-liter flask with about 1 liter absolute ethyl alcohol, until a yellow oil begins to separate at the bottom of the flask. After allowing to stand about a half hour the alcoholic solution is decanted from the oil and placed in a vessel to be recovered. The oil is now transferred to a 500 cc. beaker and washed twice with 200 cc. alcohol, decanting each time. This produces a thick syrup which is treated with 200 cc. 98% methyl alcohol. This changes it to a pasty mass to which is added about 5 cc. water. If the electrolysis is incomplete, flocculent glutamic acid will separate when the methyl alcohol treatment is begun and can be decanted with the alcohol. After again treating with methyl alcohol decanting and repeating the solution and precipitation four times, the substance is free from sodium nitrite and is a solid. It is sucked dry on a small Büchner funnel and warmed in an electric oven.

The dry substance obtained in this way is a cream-colored amorphous solid and contains impurities consisting chiefly of sodium carbonate. On solution in water a yellow liquid is obtained. This substance when sufficiently washed should not give a test for nitrite, using acetic acid for acidulation and testing with starch-iodide mixture.

Reactions.—The substance itself contains nitrogen and gives the pyrrolpine splinter test on heating.

By the Shotten-Baumann reaction with chlorobenzoyl chloride a crystalline solid is obtained, melting at 191°. This compound contains nitrogen. The corresponding glutamic acid derivative melts at 140°.

With β-naphthalene sulfochloride, a crystalline solid melting at 185–186° was obtained. This also contained nitrogen. The corresponding glutamic acid derivative melts at 163°.

When the substance dissolved in water and mixed with aniline is acidulated with hydrochloric acid below 0°, a yellow color is formed becoming deep red with excess of acid. Similarly with α-naphthylamine a deep red color is formed.

A water solution of the substance separately mixed with a solution of the following, made just acid below 0° and then alkaline, produces colors as follows: 1,8-Amido naphthol 3,6-disulfonic (H) acid, a deep blue; 1,8-dioxynaphthaline 3,6-disulfonic acid (Chromotrope), a violet; sodium β-naphtholate a yellow color. These colors do not have the intense staining qualities of the purely aromatic azo dyes.

Discussion.

It seems probable in the light of these reactions that the isoazotate of glutamic acid is formed by the above-described process. The analytical data to establish this point conclusively is not available at this time because of the extreme difficulty attending the purification of the substance for analytical purposes.

A method is now being developed to avoid decomposition and remove the inorganic matter which unfortunately has about the same solubilities as the substance in question.

It is our purpose to present in the near future the necessary analytical data to establish the constitution of this new substance as well as additional data for derivatives and new condensations. Work is under way at this time to apply this method to other suitable aliphatic amino compounds.

The writer is indebted to Mr. H. W. LeBoutellier for assistance in this preliminary investigation.

PHILADELPHIA, PA.

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DICHLOROAMINE T. AND CHLORINATED EUCALYPTOL 1.2.

BY ROBERT B. KRAUSS AND EDWARD CREDE.

Received October 19, 1917.

Since the introduction of Dichloroamine T. (Toluene-*p*-sulfondichloroamide) for the treatment of infected wounds by Dakin, Lee, Sweet, Hendricks and LeConte,[1] the production of this substance in pure form and on a large scale, as well as that of suitable solvents for its application, have become problems of importance. As originally used for this purpose, Dichloroamine T. was dissolved in a prepared eucalyptol (chlorinated) and used in this condition or further diluted with Prepared Paraffin Oil (chlorinated).

It was early recognized by the authors that the products obtained by the action of chlorine on eucalyptol may vary considerably according to the conditions of chlorination. By continued chlorination alone several preparations can be obtained, particularly chlorinated eucalyptol, specific gravity 1.2, which are at present the subject of extended study by surgeons.

The present paper is intended to describe briefly an improved method for the large scale production of Dichloroamine T., the preparation of Chlorinated Eucalyptol 1.2, as well as other results of the chlorination of eucalyptol.

Method for Large Production of Dichloroamine T.—Toluene-*p*-sulfonamide is dissolved in ten parts of 1 : 10 caustic soda (39° Bé.) and diluted with twenty parts of water. The solution is carefully filtered to remove ferric hydroxide. Chlorine from a cylinder is then passed into the solution until a voluminous white precipitate of toluene-*p*-sulfondichloroamide is formed. This, collected on a filter, throughly washed twice with 5–8 parts of water and finally with enough 10% alcohol to make a thin paste. The dilute alcohol washing should be done very quickly and the substance separated with the aid of a vacuum filter. It is then dried at a temperature not exceeding 55°, preferably in a vacuum dryer.

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[1] *J. Am. Med. Assoc.*, **69**, 27 (1917).

The method has the advantage that it is very rapid and avoids the use of chloroform as a solvent. It was developed in order to produce a Dichloroamine T. which would be comparatively stable. The product has a negligible ash and a good chlorine content, but no free chlorine on standing.

Calc.: C = 29.54%. Found: C = 29.42%, 29.37%.

The very considerable work done in this laboratory on the preparation and distribution of Dichloroamine T. for surgical purposes has suggested the following specifications as most suitable for this material when used as a disinfectant:

Physical properties:	White powder or crystals with slight yellow tinge. M. 78–84°.
Chemical properties:	Soluble in cold chloroform with slight to no turbidity. (Any turbidity must be removable by shaking with anhydrous calcium chloride.) Soluble in Prepared Eucalyptol, Dakin, and Chlorinated Eucalyptol 1.2. Ash, not over 0.2%. Chlorine content, 29.0% to 29.54%: calc.; 29.54% C.

The solubility in chloroform or similar organic solvent is important in that it shows presence of inorganic impurities, calcium salts, etc. The material should not have a strong odor of chlorine, showing instability. The melting point may vary within the limits indicated, owing to moisture. Sharp drying will decompose the substance.

The eucalyptol, as first proposed,[1] was chlorinated with potassium chlorate and hydrochloric acid according to the following method:

Five hundred cc. eucalyptol (U. S. P.) are treated with 15 g. potassium chlorate and 50 cc. concentrated hydrochloric acid. After twelve hours the oil is well washed with water and sodium carbonate solution. Dry sodium carbonate is added to the oil and the mixture is allowed to stand twenty-four hours. It is then filtered and dried with a little calcium chloride.

This method has the disadvantage that no definite amount of chlorine enters the eucalyptol. The chlorination depends on the rate of adding chlorate and hydrochloric acid as well as the light in which the process takes place. Samples may have 1% chlorine present or scarcely any, depending on whether chlorination took place in sunlight or on a dark day. The specific gravity of this oil may vary from 0.930 to 0.935.

It was found that by passing chlorine gas from a cylinder into eucalyptol the reaction proceeded much further than by the chlorate method described above. When a specific gravity of 1.20 was reached a comparatively heavy oil, much less volatile than eucalyptol, was obtained.

The results of the use of this oil will be published elsewhere; briefly, it was found that it is almost as good a solvent for Dichloroamine T.; that it can be used in full strength on the skin and in open wounds and that the use of Paraffin Oil either as a diluent or as a means of preventing sticking of dressings is unnecessary.

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[1] Dakin and Dunham, *Brit. Med. J.*, June, 1917.

The following is a sufficiently detailed statement of the method by which this oil is obtained:

Preparation of Chlorinated Eucalyptol 1.2.—Through a glass tube reaching to the bottom of a five-gallon bottle containing about 10 kilos of eucalyptol, is passed chlorine from a cylinder. The oil used should have a b. p. of 176–177° and a specific gravity of 0.925. The process should be carried on in good daylight.

During the chlorination the temperature rises and should be kept below 80° by regulating the chlorine stream. Hydrochloric acid is given off and may be absorbed in alkali.

When a specific gravity of 1.19 is reached the oil is chlorinates sufficiently and the process in interrupted. The oil is then washed with about four liters of water, then shaken thoroughly with 250 g. dry sodium carbonate and allowed to settle. After carefully decanting from the carbonate, about 500 g. fused calcium chloride are added and the whole again shaken. On standing, preferably overnight, the oil is filtered, bottled and is then ready for use. It is a white or slightly amber-colored oil, specific gravity 1.2, with a chlorine content of about 31%. Such an oil will readily dissolve 20% of Dichloroamine T., which solution may keep in an amber bottle without decomposition for a month.

Further Products of Chlorination.—By the further chlorination of the 1.2 oil, products may be obtained having a specific gravity of 1.4 and higher. This may be carried out by chlorinating directly at 100°, or with a solvent such as chloroform at its boiling point. The oil of specific gravity 1.4 is amber colored and of the consistency of molasses. The Dichloroamine is still soluble, although to a less extent. The future may find a use for this type of oil, since the increased viscosity presents an advantage in certain cases.

Summary.

In this paper is presented a method for the large production of stabile toluene-*p*-sulfon-dichloroamide (Dichloroamine T.); a method for the preparation of Chlorinated Eucalyptol specific gravity 1.2 and further chlorination products.

The constitution and properties of these oil are the subject of investigation in the laboratory. In conclusion the authors wish to thank Dr. Paul A. Lewis for his coöperation.

PHILADELPHIA, PA.

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[Contribution from the Henry Phipps Institute of the University of Pennsylvania.]

THE PREPARATION OF HALOGEN DERIVATIVES OF CATECHOL, HONO-CATECHOL AND PYROGALLOL METHYL ETHERS AND SULFONIC ACIDS.

By Robert B. Krauss and Edward Crede

Received April 21, 1917.

Introduction.—The attention of this laboratory has been directed during recent years towards the synthesis of tetrazo and disazo dyes for the purpose of chemotherapeutic experimentation on tuberculosis.

Using benzidine and its derivatives as the base, numbers of dyes have been prepared by diazotizing them and coupling to amino and phenolic second components. In order to extend a certain series of such dyes, it became necessary to prepare halogenated derivatives of the methyl ethers and of the sulfonic acids of the methyl ethers of hono-catechol, catechol, and pyrogallol. It was found advantageous in carrying out this work to modify the current methods of brominating phenols. A simplified method of preparing the dimethyl and trimethyl ethers of pyrogallol was developed. The methods of preparation for these various substances which we have found most suitable are described in the following paper.

Experimental.

Halogenation of Guaiacol Sulfonic Acids.—The guaiacol was obtained from beechwood creosote by fractionation, fractional separation by alkali and redistillation until all distilled at 205°.

The ortho and para sulfonic acids were made and separated according to the method of Hoffman[1] and Fabrik Heyden.[2] The isomers are separated best by means of the basic calcium salts, obtained from the neutral salt, by treatment with the calculated amount of calcium chloride and ammonium hydroxide, precipitating the para salt and leaving the ortho salt in solution. These are then transposed to the neutral salts. Both isomers give similar products on halogenation.

Dibromo-guaiacol Sulfonic Acid.—The potassium sulfonate is dissolved in ten parts of water and the calculated amount of bromine added drop by drop. A brown precipitate is formed. This is filtered off and recrystallized several times from hot water containing a little alcohol. The dibromo derivative separated in light brown crystalline crusts on cooling.

All halogen and sulfur determinations in this paper were made by the method of Carius. The methyl ether content where reported was determined by Zeisel's method.

$C_6HBr_2(OH)(OCH_3)SO_3K.2H_2O$.

Calculated: Br, 37.04%; S, 7.41%; H_2O, 8.02%.

Found: Br, 37.28%; S, 7.33%; H_2O, 8.02%.

Di-iodo-guaiacol Sulfonic Acid.—The iodizing of guaiacol sulfonic acids is rather difficult to accomplish. Most of the usual methods either failed to give any results or at best gave a poor yield. Best results were obtained by the method of Trommersdorff,[3] using iodine chloride. A di-iodo-guaiacol sulfonic acid was prepared in this way, the sodium salt separating as a pale yellow crystalline precipitate, difficultly soluble in cold, fairly soluble in hot water. Analysis gave the following results:

$C_6HI_2(OH)(OCH_3)SO_3Na.H_2O$

Calculated: I, 49.41%; S, 6.23%; H_2O, 7.00%

Found: I, 49.75%; S, 6.08%; H_2O, 6.77%

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[1] Ger. 109789, Friedländer V, 738.

[2] Ger. 188506, Friedländer VIII, 936.

[3] Ger. 45226, Friedländer II, 510.

Mono-bromo-creosole.—The crude fraction of creosote distilling between 218–224° C. is placed in a crystallizing dish at the bottom of a desiccator of the Hempel type. The reservoir of the desiccator is filled with moist soda-lime. A watch crystal is supported above the crystallizing dish and the calculated amount of bromine allowed to drop on the crystal slowly. The bromine vapors gradually come in contact with the creosole and are absorbed. The hydrobromic acid liberated is absorbed by the soda-lime at the top of the desiccator.

After standing about 48 hours at room temperature the mono-bromo-creosole crystallizes and can be separated by filtering on a suction filter. It is crystallized from glacial acetic acid. On recrystallizing, large colorless rhombic crystals melting at 77° were obtained. Analysis:

$CH_3C_6H_2Br(OH)(OCH_3)$
Calculated: Br, 36.87%; (OCH_3), 14.29%
Found: Br, 37.09%; (OCH_3), 14.13%

Guaiacol treated in the same manner yields dibromo-guaiacol[1] crystallizing in fine needles, m. p. 93–94°.

Pyrogallol Dimethyl Ether Sulfonic Acid.—The preparation of pyrogallol 1,3-dimethyl ether involves considerable difficulty if attempted by the usual methods. The use of an autoclave[2] and the oxidizing influence of the air[3] can be avoided by the following method:

One mol. pyrogallol is placed in a flask connected with a reflux condenser. Methyl bromide is passed into the flask by a glass tube ending in a capillary and passing through the condenser to near the bottom of the flask until the air is displaced.

Two and a half mols. metallic sodium are dissolved in twenty mols. methyl alcohol absolute. This sodium alcoholate is run into the flask together with a continuous stream of methyl bromide. The flask is heated on the water bath and the current of alkyl halide continued until the reaction is nearly neutral. The gas is rapidly absorbed and sodium bromide settles out.

The methyl ether is isolated as follows: Water is added until the sodium bromide dissolves. The methyl alcohol is then evaporated and the residue distilled in steam. Any trimethyl ether passes over in the steam. The dimethyl ether is extracted with ether after acidifying. The ether solution is evaporated and the resulting oil fractionated *in vacuo*. A colorless liquid boiling at 250° was obtained. To check the purity the methyl-ether content was determined and 40.42% : 40.31% found while the theoretical figure is 40.26%. Further methylation by the above method yields the trimethyl ether.

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[1] Cousin, *Compt. rend.*, 127, 759 (1898).

[2] Ger. 162658, Friedländer VIII, 130.

[3] Hofman, *Ber.*, 11, 329 (1878).

The sulfonation of the dimethyl ether is accomplished by treating with an equal volume of 10% fuming sulfuric acid. Heat is developed and the liquid assumes a deep red color. Sulfonation is completed by warming on the steam bath for one hour. The barium salt can be isolated by the usual method of treating with barium carbonate. It crystallizes from water in fine needles, sparingly soluble in cold, but readily soluble in hot water. Analysis:

$(C_6H_2(OH)(OCH_3)_2(SO_3))_2Ba.3H_2O$
Calculated: Ba, 20.86%; H_2O, 8.22%
Found: Ba, 20.71%; H_2O, 8.28%

Pyrogallol Trimethyl Ether Sulfonic Acid.—The sulfonation is performed as described above for the dimethyl ether. It yields a barium salt crystallizing in fine needles fairly soluble in cold and quite soluble in hot water.

$(C_6H_2(OCH_3)_3SO_3)_2Ba.2H_2O$.
Calculated: Ba, 20.54%; H_2O, 5.40%.
Found: Ba, 20.68%; H_2O, 5.49%.

Dibromo-pyrogallol Dimethyl Ether Sulfonic Acid.—The bromination is accomplished as described under dibromo-guaiacol sulfonic acid, by adding bromine to the solution of the sodium sulfonate in water. The dibromo product formed crystallizes out on standing in needles difficultly soluble in cold and slightly soluble in hot water. Analysis:

$C_6Br_2(OH)(OCH_3)_2SO_3Na.2H_2O$
Calculated: Br, 35.56%; S, 7.01%; H_2O, 8.00%
Found: Br, 34.09%; S, 6.87%; H_2O, 7.83%

Pyrogallol trimethyl ether sulfonic acid gives a dibromo derivative by the same method. This was not analyzed.

Dibromo-pyrogallol Dimethyl Ether.—If during the bromination of the sulfonic acids described above the solution is heated on the water bath, the sulfonic acid group is split off and an oil separates out.

On pouring off the water and allowing it to stand it solidifies. Crystallizing from warm alcohol it forms four-sided prisms melting at 70°. It is insoluble in water.

$C_6HBr_2 = (OH)(OCH_3)_2$.
Calculated: Br, 51.31%; (OCH_3), 19.87%.
Found: Br, 51.78%; (OCH_3), 20.33%.

Dibromo-pyrogallol Trimethyl Ether.—Using the method given above, pyrogallol trimethyl ether sulfonic acid on treatment with bromine on the water bath yields the dibromo-pyrogallol trimethyl ether. This is a crystalline solid of m. p. 75–76°. Analysis:

$C_6HBr_2(OCH_3)_3$
Calculated: Br, 49.08%; (OCH_3), 28.53%
Found: Br, 49.79%; (OCH_3), 27.70%

Summary.

In this article are described:

1. A modified method of brominating phenols.

2. A modified method of methylating phenols to prevent oxidation.

3. The preparation of dibromo-guaiacol sulfonic acid, diiodo-guaiacol sulfonic acid, mono-bromo-creosole, pyrogallol dimethyl ether sulfonic acid, pyrogallol trimethyl-ether sulfonic acid, dibromo-pyrogallol dimethyl ether and dibromo-pyrogallol trimethyl ether.

PHILADELPHIA, PA.

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NOTES.

On the Use of Large Glass-stoppered Containers in Autoclaving.—There are a large number of reactions usually carried out under pressure in sealed glass tubes. The small capacity of such tubes makes their employment for the production of larger quantities of materials costly and laborious, and one usually turns to the use of a glass enameled autoclave.

Any process in which it is necessary to heat under pressure liquids and solids in quantity may be carried out in an iron autoclave according to the following scheme: The material to be heated under pressure is placed in a glass bottle with a ground stopper. The clean, dry stopper is carefully twisted tightly into the neck of the bottle and fastened securely by a clamp of suitable design. The bottle is placed in the autoclave which is half filled with water and the apparatus then closed and heated to the desired temperature. Bottles used in this way have stood gage pressures of 5000 lbs. per sq. in., when heated in a specially designed autoclave. It is obvious that under proper conditions the internal and external pressures on the bottle are practically equal.

The autoclave constructed for us, has a maximum working pressure of 10,000 lbs. per sq. in. with a 50% factor of safety. The body of the autoclave was drop-forged from one piece of armor-plate steel and then machined.

The dimensions are as follows: Thickness of metal at all points is 2″. Inside it is 10″ in diameter and 18″ deep. Outside its diameter is 20.5″ and its height is 20″. The flange is 5″ wide. The lid is secured by 13 × 1" bolts spaced equally. The safety valve is of the ground seat type. All fittings are extra heavy $^3/_8$" pipe. The gasket of $^1/_4$" lead, whose diameters are 11" inside and 14" outside. The body is supported by a steel shell 36" high, and heated by an atmospheric gas burner.

It is located in a concrete room 10′ × 15′ × 12′, the walls of which are approximately 20" thick. This unit has been operated intermittently for about three years without mechanical difficulties.

The method has been used for the preparation of ethylene diamine from ethylene chloride and ammonia, the condensation of ethylene diamine and cantharidin, and the transposition of hydroxy R-salt to amine R-salt.

Perhaps the most interesting example involving acid conditions is the formation of diamine acridine from tetra-amine diphenyl-methane, a step in the preparation of the disinfectant flavine. About 258 g. *p,p*-diamino *o,o*-dinitro diphenyl methane are treated with 1024 g. hydrochloric acid and 232 g. of granulated tin in a porcelain dish on the steam bath. After reduction, the solution (1280 cc.) is placed in a five-liter glass-stoppered bottle and the stopper clamped on. This is placed in the iron autoclave of about 15 liters' capacity half filled with water. The closed autoclave is heated to 135° for four hours. On cooling the bottle is opened, there being no pressure within. The diamino acridine crystallizes out in the bottle and is filtered off. ROBERT B. KRAUSS.

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PARAFUCHSIN AS A STAIN FOR TUBERCLE BACILLI

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Basic fuchsin or "fuchsin for bacilli" as it is known in the bacteriological laboratory is either the hydrochlorid or the acetate of a mixture of rosanilin and pararosanilin. In this mixture the salts of rosanilin predominate. This mixed product has long been made by the oxidation of a crude anilin known as "anilin oil for red" which contains in addition to anilin, variable quantities of orthotoluidin and paratoluidin. Anilin oil for red is the result of the nitration and reduction of an impure or "crude" benzol containing considerable amounts of toluol. If instead of this "oil for red," pure anilin is used as the starting point for the manufacture of fuchsin, the resulting dye consists wholly of pararosanilin.

Under present conditions the demand for toluol in the manufacture of explosives is so great that the "oil for red" is no longer available, practically pure anilin alone appearing in the market. As soon as the supplies of fuchsin from European sources become exhausted, bacteriologists will have to use the American product, which, as has been indicated, is entirely pararosanilin.

Accordingly we have thought it advisable to examine the staining qualities of pararosanilin, particularly as to its suitability for use in the make up of the ordinary carbol fuchsin for staining the tubercle bacillus. Our examination has resulted as follows:

Pararosanilin is somewhat less soluble in alcohol than the mixed product known as "fuchsin für bac." obtained from Grübler. It is much less soluble in water and in water containing phenol and some alcohol. As a consequence of this, if any of the accepted formulas for carbol fuchsin are followed, a turbid mixture results which has no staining power because there is almost no dye in solution. The difficulty is overcome very simply by the use of a quantity of the saturated alcoholic solution twice that usually employed for "Fuchsin Grübler."

The method of employing pararosanilin is then:

1. Make a saturated alcoholic solution.
2. Add 20 cc. of this to 80 cc. of a 5 per cent solution of phenol.

The result is a clear solution of about the same color intensity as the usual carbol fuchsin. We have employed it to stain tubercle bacilli on the slide in the usual manner with complete success. When heated over the free flame the alcohol burns off and there is somewhat more rapid precipitation of the dye than there is with the old preparation. In the meantime staining has however taken place with the usual intensity and the resistance to decolorization by acids is the same.

We have not employed this stain in the manner used in many laboratories where large numbers of slides are stained at one time in an open vessel to which heat is applied, but it is to be expected that under these conditions alcohol would have to be added from time to time in order to keep sufficient dye in solution.

CONCLUSION

Pararosanilin salts have the essential staining qualities of rosanilin salts, and the tubercle bacillus when stained with them, resists decolorization with acids in the same degree. Owing to difference in solubility, the solutions of pararosanilin salts must contain more alcohol in order to be effective. A formula is given for the use of pararosanilin in the make up of carbol fuchsin.

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